UNITED NATIONS TECHNICAL ASSISTANCE
MISSION TO YUGOSLAVIA

SISTEM ZA IZVOZ ELEKTRIČNE ENERGIJE IZ JUGOSLAVIJE

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

A. V. Karpov
Consulting Engineer

Belgrade
May 1953

Institut za tehničko-ekonomska istraživanja
Srpske Akademije Nauka

UNITED NATIONS TECHNICAL ASSISTANCE
MISSION TO YUGOSLAVIA

Belgrade,
May 26th, 1953

Dear Dr. Han;

In accordance with your request I have studied the problem of the Export of Electric Energy from Yugoslavia. This study included visits and personal inspections of the power plants and power plant sites involved. The results of my studies are summarized in the Recommendations and Report : "EXPORT OF ELECTRIC ENERGY AS AN IMPORTANT FACTOR IN THE INDUSTRIALIZATION AND ECONOMIC DEVELOPMENT OF YUGOSLAVIA". The study convinced me of the importance of the Export of Energy, the feasibility of the export scheme and the possibility to start the export within so short a time as two years.

The recommended export scheme is an undertaking of considerable magnitude, probably one of the largest single new undertakings in Yugoslavia. The time at my disposal was exceedingly limited; it was, therefore, impossible for me to go into details of the export scheme to an extent that a project of such importance would require. My report gives only the general outline and the methods which should be used in handling the problem.

As I have already pointed out on many occasions, the successful, speedy and economic realization of such a project will require a very considerable amount of work to clarify the numerous problems, and to avoid mistakes which may be exceedingly costly.

In that connection I should like to stress once more that projects of that kind cannot be handled in a disjointed manner by a number of organizations acting practically independently and without centralized guidance. The most important problem of today is to create a centralized energy export agency and to staff it properly so as to obtain an organization of a superior kind to which the handling of a problem of such magnitude and importance could be entrusted.

I wish to take this opportunity to tell you how much I appreciate the assistance which I got from you personally, from the members of your organization and from the numerous persons who assisted me in my field work and in the office. Without such help it would have been impossible to make the Recommendations and the Report that I am attaching hereto.

I am authorized to leave the Recommendations and the Report with you with the distinct understanding that they are of preliminary nature only and may be considered as final if and when aproved by the Technical Assistance Administration of the United Nations. These Recommendations and the Report are being translated into Serbian.

With kind regards

Sincerely yours

A. V. Karpov,
Consulting Engineer

Dr. Stjepan Han
Direktor
Instituta za Tehničko-Ekonomska
Istraživanja - Beograd

United Nations Technical Assistance
Mission to Yugoslavia

SISTEM ZA IZVOZ ELEKTRICNE ENERGIJE IZ JUGOSLAVIJE

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

R E C O M M E N D A T I O N S

By

A.V. Karpov,
Consulting Engineer

Belgrade
M a y 1953

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

R E C O M M E N D A T I O N S

I

The importance of exports of electric energy for the economic development of Yugoslavia and the need to start them at the earliest possible opportunity should be recognised.

The four rivers: Cetina, Neretva, Trebišnjica and Zeta, and the Bohinj Lake should be designated as sources of energy to be reserved exclusively for export purposes as outlined in the report "Export of Electric Energy as an Important Factor in the Industrialisation and Economic Development of Yugoslavia".

II

The Electric Energy Export System of Yugoslavia "Sistem za izvoz električne energije iz Jugoslavije" (SIEEJ) should be organised at the earliest possible date. The appointment of the Chairman, Chief Engineer and of the necessary staff should follow without delay. The general outlines of the system recommended in the report as it should be developed by the year 1955 and up to and including the year 1961, are shown in the attached maps Fig. 1 and 2 - "Recommended System Development 1955" and "Recommended System Development 1961". The years of initial delivery of each project and the amount of energy that could be generated for export during each of the years 1955-1956 inclusive are given in the attached Table I.

III

Yugoslavia should take the initiative in the matter and submit definite proposals as to the amount of energy to be delivered annually during the next few years.

The projects, specifications, and operation schedules of the system should be immediately worked out by the ISEEJ and submitted for discussion to the international commissions.

IV

A foreign currency loan agreement should be negotiated so that the first installment of the loan could be made available by the middle of 1953. In this case the exports of energy could be started at an annual rate of about 1,000 Million KWh as early as in winter 1955-56 reaching the maximum level of about 10,000 million KWh in the course of the year 1961-62. The above level is to be maintained in the subsequent years. These amounts of energy correspond to a year of average water flow.

V

The loan agreement should preferably provide for a long term foreign capital loan to be made available in annual installments in the course of the next seven years. The proceeds of the loan will be augmented by investing a large part of the system's profits as shown in the two financial schemes, Variants "A" and "B", in the attached Table II. Such a financing arrangement would make it possible to start the work on the whole system at once.

If a foreign currency loan could be arranged on the basis indicated in Variant "A" and if Yugoslavia is able to provide the local funds, an Energy Export System that would cost

315 Million Dollars plus 219 000 Million Dinars

could be built in Yugoslavia by investing the sum of

219 000 Million Dinars

during the years 1953-1961 and by paying in annual installments out of the income of the system a total sum of

296 Million Dollars

during the years 1958-1983.

If Variant "B" is accepted the same Energy Export System will require the investment of

167 000 Million Dinars

during the years 1953-1959 and the repayment from the income of the system of a total

sum of

384 Million Dollars

in annual installments during the years 1959-1984.

VI

If a straight loan could not be arranged, a combined foreign capital and machinery and equipment loan should be concluded.

The ISEJ should prepare a list of equipment and materials that will be necessary for the construction of the system. The list should be divided into two parts:

1. Equipment and materials to be supplied from abroad;

2. Equipment and materials to be obtained in Yugoslavia.

The loan should be so negotiated as to arrange for the supply of all or part of equipment and materials to be listed under 1.

VII

An energy delivery contract should be worked out in connection with the loan agreement on the basis of proposals made by Yugoslavia. An agreement should be signed with Italy, Germany and Austria specifying the selling prices of guaranteed and non-guaranteed winter and summer energy that Yugoslavia would undertake to deliver within regular intervals in the course of the next few years. The price of energy should be higher during the construction period and there should be a considerable difference in price between the energy delivered during the winter and summer periods.

VIII

The agreed upon price of winter and summer energy should be of such an order that a profit large enough to make the proposition attractive for Yugoslavia could be obtained on it during the operation period. Table III gives the approximate cost and values of energy exported during a low water year. This table reflects the advisability of obtaining a higher price for the energy during the construction period so that the earnings in foreign currency could be immediately reinvested. During the high reinvestment years 1955-1959 it would be

reasonable to reduce the profit margin. A major part or even the whole of the income obtained in these years as a result of the higher energy price should be reinvested in the system.

IX

The loan and the energy selling agreements should be reached by negotiations only. The amount of local currency that could be invested and reinvested must be fixed by the Yugoslav financial experts. It is, therefore, impossible to make very definite recommendations on these matters. The general outlines given in these Recommendations and discussed in more detail in the Report, if incorporated in the agreements, will effectively protect the interests of Yugoslavia. How far that can be accomplished and how much can be incorporated in the agreements that will finally be reached, depends on the skill of the Yugoslav representatives conducting international negotiations and on the quality and extent of information that the ISEEJ will put at their disposal.

A T T A Ç H M E N T S

Table I

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

Initial Years of Delivery and Approximate Total Yearly Export Generation.

	Year of initial delivery	Project	Average yearly export generation per project 1000 Million KWh	Total yearly export generation 1000 Million KWh
1.	1955	Jablanica	0.77	
2.	1955	Slovenia System	0.33	1.10
3.	1956	Zeta without storage capacity	0.60	1.70
4.	1957	Ulog	0.55	
5.	1957	Zeta with First Step of Storage	1.10	2.35
6.	1958	Glavatičevo	0.40	
7.	1958	Zeta Second Step of Storage capacity	0.40	3.15
8.	1959	Rama	0.70	
9.	1959	Cetina River First Step	2.00	5.35
10.	1960	Trebišnjica	2.35	8.20
11.	1961	Remainder of Neretva River plants	1.90	10.10

Table II

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

Financial Arrangements Variants "A" and "B"

Foreign Currency -

Year	Million Dollars					
	Loan		Reinvestment		Total	Cost of completed portion of system
	Variant A	Variant B	Variant A	Variant B	Variants A & B	
1953	60.00	60.00			60.00	
1954	60.50	60.50			60.50	
1955	31.00	39.25	16.50	8.25	47.50	40.06
1956	11.60	24.45	25.60	12.75	37.20	63.65
1957	0.30	17.90	35.20	17.60	35.50	86.15
1958		5.45	29.00	23.60	29.00	99.75
1959			24.50	24.50	24.50	177.90
1960			15.50	15.50	15.50	251.90
1961			5.00	5.00	5.00	314.70
Total	163.40	207.50	151.20	107.20	314.70	
Financial charges	132.72	176.90				
Total	296.12	384.40				

Local Currency -

Year	Million Dinars					
	Loan		Reinvestment		Total	Cost of completed portion of system
	Variant A	Variant B	Variant A	Variant B	Variants A & B	
1953	39 000	39 000			39 000	
1954	43 000	43 000			43 000	
1955	33 500	30 200			33 500	29 000
1956	26 500	21 400		5 100	26 500	48 000
1957	26 000	19 000		7 000	26 000	64 000
1958	21 500	12 000		9 500	21 000	74 000
1959	17 500	2 500		16 000	18 500	128 000
1960	7 500			7 500	7 500	181 000
1961	3 500			3 500	3 500	219 000
Total	219 000	167 100		51 900	219 000	

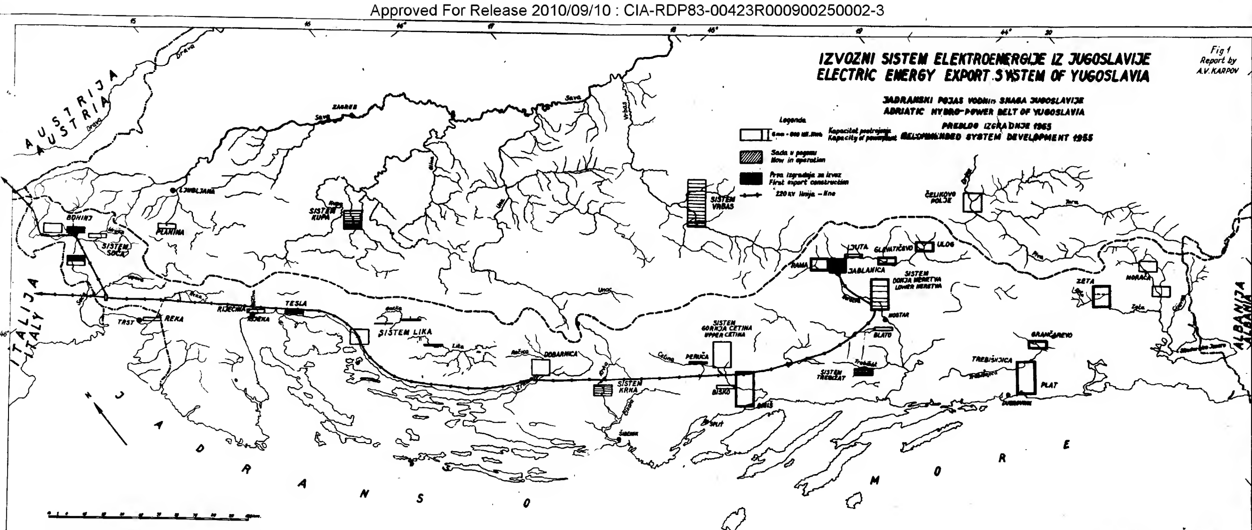
Table III.

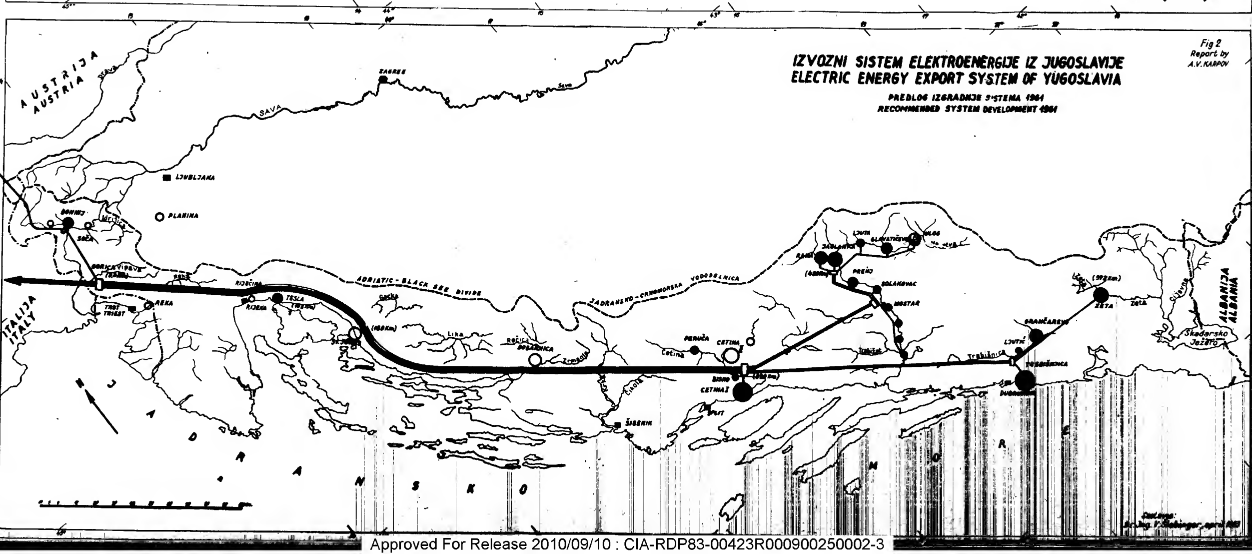
ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

Approximate Cost per KWh and Total Value of Exportable Energy

Low Water Year

Export 1000 Million KWh	Variant "A" Cost of Energy Mils per KWh	Variant "A" Value of Energy Million Dollars	Variant "B" Cost of Energy Mils per KWh	Variant "B" Value of Energy Million Dollars	Variants "A" & "B" Cost of Energy Dinars per KWh	Variants "A" & "B" Value of Energy Million Dinars
			Construction Period			
0.83	21.23	18	11.23	9	1.05	1 000
1.28	21.29	26	11.29	24	1.05	1 500
1.77	21.26	37	11.26	20	1.13	2 000
2.36	16.60	39	11.10	26	0.99	2 300
4.02	12.04	48	11.39	46	0.98	4 000
6.15	6.77	41	7.34	45	0.91	6 000
7.57	4.30	33	5.39	41	2.25	17 000
			Operation Period			
7.57	4.27	32	4.43	34	3.15	24 000
7.57	3.90	30	4.06	31	2.94	22.200
7.57	3.58	27	3.68	29	2.73	20 600
7.57	3.23	24	3.31	25	2.53	19 200


IZVOZNI SISTEM ELEKTROENERGIJE IZ JUGOSLAVIJE
ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA
JADRANSKI POJAS VODNIH SNAGA JUGOSLAVIJE
ADRIATIC HYDRO-POWER BELT OF YUGOSLAVIA
PREDLOG IZGRADNJE 1955
RECOMMENDED SYSTEM DEVELOPMENT 1955
Legenda
Kapacitet postrojenja
Kapacity of powerplant
Sada u pogonu
Now in operation
Prva izgradnja za izvoz
First export construction
220 KV linija – line
Fig 1
Report by
A.V. KARPOV
AUSTRIJA
AUSTRIA
ITALIJA
ITALY
ALBANIJA
ALBANIA
ZAGREB
LJUBLJANA
SISTEM SOČA
PLANINA
SISTEM KUPA
SISTEM VRBAS
TRST
REKA
RIJEKA
TESLA
SISTEM LIKA
DOBARNICA
SISTEM KRKA
PERUĆA
SISTEM GORNJA CETINA
UPPER CETINA
RAMA
JABLANICA
GLAVATIČEVO
ULOG
SISTEM DONJA NERETVA
LOWER NERETVA
MOSTAR
BLATO
ČELIKOVO POLJE
ZETA
MORAČA
GRANČAREVO
TREBIŠNJICA
PLAT
DUBROVNIK
ŠIBENIK
SPLIT
J A D R A N S K O
M O R E
Sastavio Dr. Jng. V. Šlebinger


IZVOZNI SISTEM ELEKTROENERGIJE IZ JUGOSLAVIJE
ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA
PREDLOG IZGRADNJE SISTEMA 1961
RECOMMENDED SYSTEM DEVELOPMENT 1961
Fig 2
Report by
A.V. KARPOV
AUSTRIJA
AUSTRIA
ITALIJA
ITALY
ALBANIJA
ALBANIA
ZAGREB
SAVA
LJUBLJANA
PLANINA
BOHINJ
SOČA
GORICA
TRST
TRIEST
REKA
RIJEKA
TESLA
DOBARNICA
PERUĆA
CETINA
ŠIBENIK
SPLIT
ADRIATIC - BLACK SEA DIVIDE
JADRANSKO - CRNOMORSKA VODODELNICA
RAMA
JABLANICA
LJUTA
GLAVATIČEVO
ULOG
MOSTAR
GRANČAREVO
LJUTA
TREBIŠNJICA
DUBROVNIK
ZETA
Skadarsko Jezero
J A D R A N S K O
M O R E

United Nations Technical Assistance
Mission to Yugoslavia

SISTEM ZA IZVOZ ELEKTRIČNE ENERGIJE IZ JUGOSLAVIJE

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

EXPORT OF ELECTRIC ENERGY AS AN IMPORTANT FACTOR IN INDUSTRIALIZATION AND ECONOMIC DEVELOPMENT OF YUGOSLAVIA

Report

by

A.V. Karpov,
Consulting Engineer

Belgrade
May 1953

C O N T E N T S

A T T A C H M E N T S

LIST OF TABLES

L I S T   O F   F I G U R E S

Approved For Release 2010/09/10 : CIA-RDP83-00423R000900250002-3

A. INTRODUCTION

Due to favourable topographic and rainfall conditions, a large amount of ydro-power possibilities is available in Yugoslavia on a comparatively small area 257.000 km^2). It is estimated that it would be economic to develop 9 million kw and to generate 52 billion kwh in an average year. The expectations are that the industrialisation of the country will develop to such an extent that it will be possible to utilise all the hydro-power available within the country. It is obvious, however, that a few decades will pass before the industrialisation has advanced to a point when it would be possible to utilise such an amount of energy in Yugoslavia. The problem that now confronts Yugoslavia is, therefore, either to develop hydro-electric projects slowly, so as to meet only the needs of home industries and let the surplus of water go to waste, or to develop hydro-electric possibilities quickly and export a part of the energy produced until such time when domestic use will have increased sufficiently to absorb all the energy produced.

At present, a considerable shortage of power is developing in the industrialised countries of Europe and demand for power is and will be such that imported energy would always find a profitable market there.

The foreign countries bordering Yugoslavia on the north are Northern Italy and Austria. Most of the energy consumed in these countries is being generated in the Alps. Moreover, energy generated in the Alps feeds Switzerland and to a substantial extent Germany. All the four countries could be considered as prospective consumers of energy to be directly or indirectly imported from Yugoslavia.

In commercial intercourse between contries, just as between individuals or organisations, it is necessary for the supplier to study and understand market conditions. Such a study should be undertaken so that no point of advantage be missed by the Yugoslav representatives who will conduct negotiations with the the countries concerned.

All the countries in which a substantial part of energy is generated in the Alps are dependent on the peculiarities of the waterflow in the alpine rivers. In this region, most of the precipitation in winter is in the form of snow which accumulates on the mountain slopes and in the valleys. The possibility of energy generation in the Alps in winter months is, therefore, small.

In summer, to the contrary, not only normal rainfall water is available, but very large amounts of water are obtained in addition to it from melting snow. For this reason there is a scarcity of electric energy in winter and an abundance of it in summer in the region of the Alps. To equalise the summer and winter conditions it would be necessary to provide large storage reservoirs in which water could be accumulated during summer to be used in winter months of water scarcity.

The industrial countries of Europe are highly developed and densely populated. It is therefore very difficult, in fact impossible, to create sufficiently large storage reservoirs. The actual remedy would be to build thermoplants the operation of which is very expensive in Central and Southern Europe. As a result of all these considerations, there is a very substantial difference in price between the energy that could be bought in winter and that supplied in summer.

There are instances when European countries find it profitable to pay five times as much per kwh of energy delivered in winter as they do in summer. It is not likely that the difference in cost between energy supplied in winter and summer will decrease. With the development of the countries concerned the shortage of winter energy will become more acute and it may be expected that the difference in price will further increase or, at least, remain on the same level as at present.

These market conditions create a peculiar problem for prospective suppliers of energy, as for instance, Yugoslavia. It is obvious that no particular advantage could be gained by supplying summer energy.

Yugoslavia has two possibilities : either to create large storage reservoirs in which water could be accumulated, or to exploit the peculiarities of the Adriatic drainage basin. In this basin comparatively little snow is accumulated in winter and a major part of water feeding its rivers comes from abundant rainfall during the cold season. The moisture-saturated clouds coming from the Adriatic discharge rain over the western slopes of the Dinar Mountains and the watercourses fed by these rains flow back into the Adriatic Sea. Rivers in other parts of Yugoslavia do not have such a pronounced abundance of water in winter; their summer flow is often more plentiful though it seldom reaches the same degree of abundance as that observed in alpine rivers in summer.

In general, it may be stated that the difference in price of summer and winter energy presents a considerable advantage to Yugoslavia and no measures should be supported by Yugoslavia that would tend to reduce it.

Practically, that would mean that any accumulation of water during summer

that would permit increased energy generation during winter should be so far as possible done in Yugoslavia. That in turn should mean that Yugoslavia ought to export a minimal amount of energy during summer. Any excess in Yugoslav exports of low cost summer energy would make it possible for the energy consuming countries to improve their summer accumulation of water and, therefore, increase their own generation of high cost winter energy.

The market conditions in Southern Europe indicate, therefore, the advisability of supplying the largest possible amounts of winter energy and of reducing to the minimum the amounts of summer energy exports.

If a speedy development of the major hydroelectric projects of Yugoslavia were attained it could be possible to arrange a power export set-up most favourable to Yugoslavia. For the next decade or two Yugoslavia would supply a gradually increasing amount of winter energy and a very small amount of summer energy. When all Yugoslav power export possibilities will have been utilised for a few years, no further increase in the amount of exported energy should be expected. After that a gradual decrease of power export would set in as by that time the industrialisation of Yugoslavia will have made sufficient headway.

Ultimately, when Yugoslavia is able to consume all its energy, only an exchange of energy with foreign countries will still be possible, - Yugoslavia exporting a large amount of winter energy and importing a corresponding amount of summer energy. At the stage of development, however, when Yugoslavia would balance her imports and exports of energy, the payment position would be very advantageous for it, owing to the high cost of winter energy, and the comparatively low price of the summer energy.

The economic advantages, both present and future, of developing such an energy export-import pattern in Yugoslavia are so obvious that the speeding up of construction of electric energy projects should undoubtedly be given first priority, so that the export of energy might be started as early as possible.

B. RIVER REGIMES OF YUGOSLAVIA

Some of the rivers in Yugoslavia have a waterflow of the alpine type characterised by small discharges in winter and large ones in summer. Most of these rivers originate or flow in the Republic of Slovenia. The rivers of the Adriatic drainage basin, to the contrary, have larger discharges in winter and smaller ones in summer. The rivers belonging to the Black Sea and the Aegeian drainage basins have less variation between the winter and summer duscharges although some of them have very small summer discharges.

The attached diagram "Hydrographs of Alpine and Mediterranean Type of Rivers" gives a comparison of the water discharges of the Drava River (typical of the alpine category) with those of the Cetina River, which can be considered as a typical Adriatic drainage basin river.

A study of that diagram shows how the Adriatic coast rivers can be used to cover the deficiencies in winter generation of the alpine rivers. It may also be perceived that it would not be possible to utilise any of the Adriatic coast rivers rationally and without water losses unless sufficient storage capacity has been provided. When storage capacity is available, the water peaks can be stored in reservoirs and utilised for energy generation.

If the alpine rivers are to be utilised for energy generation during winter, very large storage capacities will be required. Much smaller storage capacity would be necessary for the summer utilisation of these rivers.

The Adriatic drainage basin rivers to the contrary can deliver winter energy with a comparatively small storage capacity. If they are to deliver large amounts of energy in summer, very large storage basins will be required.

The energy generation capacity of the three basins into which Yugoslavia can be divided is as follows :

Drainage Basin	Theoretical Million KWh	Practical Million KWh
Black Sea	72 000	30 000
Adriatic Sea	30 500	19 000
Aegeian	6 500	3 000
	109 000	52 000

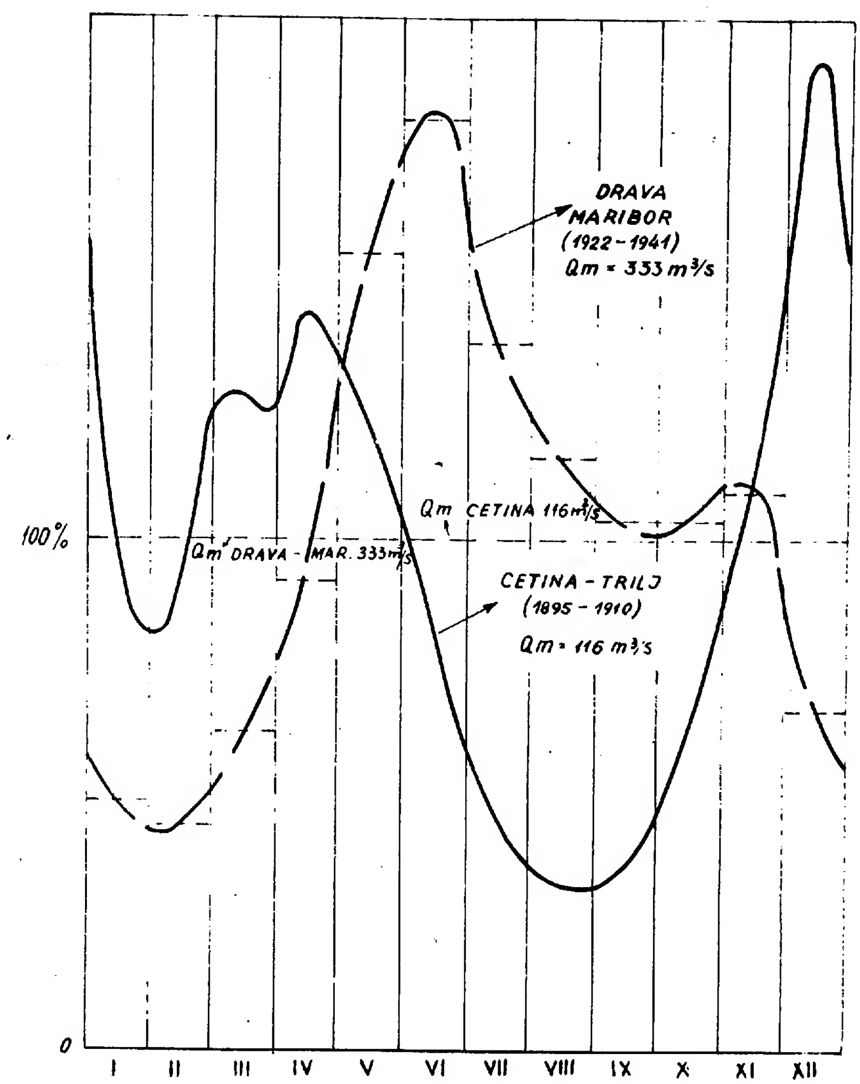
The theoretical generation estimates are based on the total estimated average amounts of water and head available. The practical generation estimates are a summarisation of the generation capacity of projects that have already been investigated.

The attached "Map of Gross Water Power Resources" indicates the locations of the power resources. (Fig. 4)

Fig 3
Report by
A.V. KARPOV

HIDROGRAFI
ALPISKOG I PRIMORSKOG
TIPA REKA

HYDROGRAPHS OF ALPINE AND
MEDITERRANEAN
TYPE OF RIVERS



IZRADIO Dr. Jng. V. Šlebinger


Hidrometeorološka služba FNRJ
KARTA
FNR
JUGOSLAVIJE
Fig 4
Report by
A.V. KARPOV
KARTA BRUTO VODNIH SNAGA
MAP OF GROSS WATER POWER RESOURCES
LEGENDA:
KONCENTRACIJA ENERGIJE OD 10000 Kwh
POWER CONCENTRATION OF
1/2 FNRJ, 1/2 INOSTRANSTVO
1/2 YUGOSLAVIA, 1/2 FOREIGN
VODNE SNAGE SUSEDNIH DRŽAVA
WATER POWERS OF NEIGHBORING COUNTRIES
VODNE SNAGE KRAŠKIH TOKOVA
WATER POWER OF UNDERGROUND (KARSTIC) STREAMS
Obradio 1946g. Dr. Jng. V. Šlebinger
LJUBLJANA
ZAGREB
Maribor
Varaždin
Gorica
TRST
Rijeka
Karlovac
Pula
Bihać
Banja Luka
Virovitica
Osijek
Brod
Subotica
Sombor
Zrenjanin
NOVI SAD
DUNAV
SAVA
BEOGRAD
Šabac
Tuzla
Valjevo
Zadar
Šibenik
Split
Travnik
SARAJEVO
Mostar
Dubrovnik
Titovo Užice
Kragujevac
Požarevac
Negotin
Zaječar
Niš
Pljevlja
Sjenica
Leskovac
Dimitrovgrad
PRIŠTINA
Peć
Vranje
TITOGRAD
SKOPJE
Kumanovo
Titov Veles
Prilep
Ohrid
Bitola
Strumica
A
D
R
I
A
N
S
K
O
M
O
R
E

C. HYDROELECTRIC ENERGY SOURCES

When the hydroelectric sources for domestic and export requirements are ing considered, they could be divided into three categories :

a. Run-of-river plants on rivers having a larger water flow in summer d a smaller one in winter.

b. Run-of-river plants on rivers having a large winter water flow and a nall summer flow.

c. Storage power plants in which water can be accumulated during high ter season and discharged to the power plants at such times when energy is most eded.

Each of these kinds of power plants has its place in the power development of Yugoslavia provided a proper balance has been attained that would answer e requirements of overall energy demand in the country.

No particular importance should be attached to the theoretical amount energy that can be generated. This figure has no significance. It is important know the amount of energy that can practically be generated and consumed.

In Yugoslavia today there is a tendency to build a large number of run--river plants. Theoretically a considerable amount of energy could be generated these plants. Practically, the amount of energy that could be generated and nsumed is much smaller. There is no possibility to adjust the load to quickly hanging river flow conditions. The only method by which the generation of run-of-iver plants can be fully utilised is to provide a balancing energy source which ould have the task to keep the energy generation more uniform. Such a regulating lant would supply energy during the low water season and may be shut down during igh water periods. Thermoplants or water storage plants can be used for this purose. In Yugoslav conditions thermo-plant energy is expensive; it is necessary, herefore, to determine the extent to which it would be economical to build stoage power plants in preference to thermo-plants.

Such regulating power plants are of particular importance in connection ith the energy export problem. No energy importing country could afford to pay a igh price per kwh of energy for irregular and varying supply, at a time when it eeds a more uniform flow of energy. Each energy importing country, however, will e prepared to pay a high price for a specified amount of energy to be delivered ithin a specified period under the stipulated provision of a specified uniformity f supply.

D. WATER STORAGE

The difference in cost between winter and summer energy and the necessi- to provide a certain flexibility of operation makes it hig y desirable to uti- se the available water storage possibilities up to the economic limit. This is point that was not taken into consideration in Yugoslavia in the past. In most stances it was thought that if a sufficient storage capacity could be provided equalise the energy delivery curve through the year, the situation could be nsidered satisfactory. In order to export energy it is necessary to assure as gh a winter delivery as is economically possible, with a corresponding decrease summer energy delivery. Every water storage project in Yugoslavia should be re- sed and the economically possible highest water storage developments utilised. is concerns all the projects in Yugoslavia. If considerable amounts of winter ergy are to be exported from Yugoslavia and available large water storage re- rvoirs utilised for this purpose, a large number of small storage reservoirs uld be helpful in providing for a more uniform domestic energy delivery.

E. PARALLEL DEVELOPMENT COVERING DOMESTIC AND EXPORT REQUIREMENTS

In order to assure profitable exports of energy without decreasing the rate of industrialisation of the country it is necessary to work out a balanced development of various projects. Energy exports will require the concentration of a large amount of energy delivery at the points where the energy is to be transmitted across the borders of Yugoslavia. The domestic supply will require an extensive transmission system which might ultimately service the whole country. In the domestic supply the importance lies not in the concentration of large amounts of energy at a few points but to the contrary in the supply of small amounts of energy at a very large number of points.

The difference in the pattern of energy supply for export and for domestic consumption more or less governs the selection of power plants for exports and for domestic purposes.

The export of energy should be supplied from a comparatively small number of large power plants capable of delivering large amounts of energy during winter. The domestic demand can be covered by a large number of smaller plants that would supply a reasonably uniform amount of energy both during the winter and summer seasons.

F. THE YUGOSLAV ADRIATIC HYDRO POWER BELT AND THE "YUGOSLAV ELECTRIC ENERGY EXPORT SYSTEM"

The meteorological and topographic conditions along the Adriatic coast f Yugoslavia are such that power plants can be built there which would be more uited for supplying export energy than any other plants in Yugoslavia. The Yugo-lav Adriatic Sea drainage basin includes the part of the Adriatic Sea drainage asin that lies on the Yugoslav territory. It is bordered by Albania on the south d by Italy on the north-west. In Yugoslavia it is limited by the divide line tween the Adriatic Sea and the Black Sea drainage basins.

Considerable amounts of hydro electric energy could be developed in is belt. Hydroplants of this region would be able to deliver a much larger per-ntage of winter energy than in any other part of Yugoslavia. This advantage is e to the character of the rivers in the Adriatic Sea belt. The natural water low pattern in these rivers could be further improved by using storage reservoir apacities which are also available in this region.

The main difficulty which should be taken into account is the nature f limestone formations here some of which are very strongly karstified. This oes not preclude the erection of developments, but will certainly increase their ost, in some instances to quite a large extent.

In spite of this, the Adriatic hydro power belt of Yugoslavia may on he whole be considered as an unusually attractive potential source of electric energy exports to Italy, Austria, Germany and Switzerland.

It would be a grave mistake, however, to underestimate the technical difficulties that have to be overcome in order to set up an energy export scheme. None of these difficulties are unsurmountable, but a most careful consideration should be given to all factors involved.

It will be necessary to keep large power plants strung along a tran-mission line in the Yugoslav Adriatic Belt in parallel operation with the power ystems of Italy and Austria. The distance between the farthest removed Yugoslav ower plant and the nearest point of the Italian and Austrian transmission systems ill be about 580 km. Along these 580 km the transmission system at the Yugoslav nd will not distribute but only collect energy at a number of points. The voltage

and other regulations of such a system and its maintenance in satisfactory operation will involve the use of the latest regulation facilities and a superior communication system connecting the chief dispatcher's office of the Yugoslav Electric Energy System with all the other plants as well as with the chief dispatcher's offices of the Italian and Austrian power systems.

The energy export system to be developed in Yugoslavia will be so unlike any other existing system of this kind that the experience gained in this field in the past would provide very little guidance.

The most important problem would be to keep the energy export system separated from the local distribution systems. No troubles in the local system should be allowed to interfere with a smooth operation of the export system.

It, therefore, becomes a requirement of first importance to keep the export system practically isolated from all other Yugoslav distribution systems.

It will be necessary to select and designate a number of power plants in the Adriatic Hydro-power Belt which would be entirely devoted to the generation of energy for export purposes. These plants would be under the direct management of the energy export organisation which is to be directly responsible for their operation. The energy exporting plants should be connected by a special high tension transmission line. Connections to any local system should be considered as emergency connections only and ought not to be operative during the normal operation of the system.

As time goes on, and when practical experience has been gained in the operation of an export circuit, decisions could be taken with regard to increasing the number of emergency connections.

It will therefore be advisable to assign a number of power plants in this belt for energy export purposes. Local requirements may be supplied from the remaining plants of that belt and from the plants located in the Black Sea drainage basin.

Upon careful consideration it is recommended that the following projects be included in the first step :

"Electric Energy Export System of Yugoslavia"

1. Zeta River Projects
2. Trebišnjica River Projects
3. Neretva River Projects

4. Cetina River Projects

5. Bohinjsko Jezero Plant

A combination of these projects will provide the most favourable energy export pattern. The Electric Energy Export System should have complete control not only over the power plants assigned to the export scheme, but also over every single other plant on the above mentioned rivers.

Fears that the Energy Export Scheme might interfere with the industrialisation and development of local industries in the Adriatic Hydro Power Belt are quite groundless. There will be plenty of opportunity to supply the local needs from other sources not included in the Energy Export Scheme.

As time goes on and the operation of the system develops, it may prove advisable to increase the exports of energy. In such a case additional power plants should be assigned to the Energy Export System.

Large amounts of energy will have to be supplied for export during the six winter months. The difficulties in operation will be considerably reduced if the number of energy supplying plants is kept as small as possible. At the same time, the number of turbine-generator aggregates and transformers should also be reduced to a minimum. In other words it would be advantageous to utilise the largest aggregates obtainable within manufacturing and transportation limits. These large aggregates should be installed in a small number of large power plants. These plants would be larger than anything ever attempted in Yugoslavia before and in the order of the largest hydro-electric power plants in Europe.

To make the operation possible it will be necessary to provide not only very large but also very sensitive turbo-generator aggregates. The turbines of these aggregates should have a very short closing time and the aggregates themselves - a very quick response to the action of speed and voltage regulators.

The high water velocities that are at present being accepted in the projects in waterways approaching the turbines make it impossible in many instances to maintain the necessary high regulation sensitivity of the turbines. In export plants considerable attention should be given to reducing the water velocities to such an extent as to assure the necessary degree of high regulation sensitivity of the turbines.

G. SEQUENCE OF CONSTRUCTION AND INITIAL OPERATION OF PROJECTS

When making arrangements for energy exports two major requirements must be satisfied :

1. To keep meticulously to the stipulated dates and minimum amounts of energy deliveries;
2. To supply from the outset considerable blocks of energy and then gradually increase the amount of energy supplied.

The first requirement is obvious. In dealings between independent countries each partner must be confident that the other will keep the agreed upon terms. If such a confidence is lost, the relations between the country supplying the energy and the country receiving it cannot be maintained on a mutually satisfactory level. The countries importing the energy will try to make other arrangements that they might consider more reliable, in order to protect their industries and assure their economic development.

The second requirement is of unusual importance. If Yugoslavia could start to deliver energy within the next two or three years, a very favourable agreement could be reached between Yugoslavia and the energy consuming countries. Any further delays of the initial delivery date would cause the energy receiving country to make some other arrangements that would be to the direct disadvantage of Yugoslavia.

It is, therefore, necessary to work out a scheme of energy exports that would on one hand make possible an early start of energy deliveries and on the other hand be set on a realistic basis, so that the terms of agreement could actually be adhered to.

The construction of power plants has already reached and advanced stage both in Bosnia an Herzegovina and in Slovenia. The plants in these Republics could and should be utilised to speed up the beginning of export operations. The Jablanica power plant could be suggested as the key plant for the initiation of energy export. As outlined in the attached report, entitled "Export of Electric Energy From the Neretva River Basin", the changes necessary to make it an energy export plant can be well accomplished within two years. If the decision is made and the funds provided without delay, this plant could be put in operation and start to supply energy in the course of the winter 1955-56.

The average yearly energy output of about 700 million kwh of the Jablanica Plant could be supplemented by about 300 million kwh to be supplied by Slovenia. For this purpose it would be advisable to build without delay the Bohinjsko Jezero Plant which could be completed within two years. Besides this, it might be possible to obtain additional energy from some of the Slovene run-of-river plants and use the Jablanica storage to level off the delivery curve.

As outlined in the attached report entitled "Export of Electric Energy From the Zeta River Basin", the Zeta power plant, working as a run-of-river plant, could start to deliver 600 million kwh in the winter months of 1956.

In 1957, the Ulog storage plant on the Upper Neretva could supply 550 million kwh and at the same time improve the delivery of energy by increasing the storage capacity of the system. The same year, the completion of the first step of the Zeta storage project would make it possible to increase the delivery of the Zeta plant by another 100 millions kwh.

In 1958, the Glavatičevo storage plant on the Upper Neretva could provide an additional 400 million kwh and at the same time improve the storage facilities of the system. During the same year it would probably be possible to add another 400 million kwh by putting in operation the second step of the Zeta River Project.

In 1959, the Rama plant could add another 700 million kwh and contribute to a further enlargement of storage facilities of the system.

The building of a dam and power plant at Peruča or Obrovac on the Cetina River and of another power plant near Split could be started at a very short notice. This might be considered as the first step of the Cetina project. The second part of this project could not be started until the completion of investigation which might take a few years. The Cetina River itself does not present any unusual difficulties. The sealing of the karst plains at the higher elevation will, however, involve a considerable amount of investigation and testing. Thus, the project included in the first step of the Cetina River development could start to deliver about 2 billion kwh already in 1959. The date of starting of further energy delivery from the Cetina could be determined only after the detailed investigations have been completed.

In 1960 the Trebišnjica River plants could start to deliver 2.35 billion kwh.

In 1961, the remainder of the Neretva River plants would add a further billion 900 million KWh to the total delivery.

The proposed sequency of initial delivery dates and the amounts of ener- to be delivered annually in 1955-61 are summarised in Table I included in the oommendations: "Initial Years of Delivery and Approximate Total Yearly Exports".

The data contained in the abovementioned table must be considered as ovisional estimates only. It is possible that in some instances the amount of ergy delivered could be larger and in some smaller. The available water flow ta do not cover sufficiently long periods of time and are not sufficiently re- able to allow any definite conclusions to be made.

Transmission losses have not been deducted, so that the net amount of rgy delivered to the foreign countries will be below that given in the above ble.

The approximate distribution of energy exports between the winter and mer months is given in the attached Table IV: "Approximate Yearly Winter and mer Export Generation". This table must also be considered as a provisional imate only. It may be that, when the projects have been designed and built the maximum economic storage capacities utilised, it will be possible to fur- r increase the amount of winter energy and correspondingly decrease the amount summer energy.

The potential initial delivery dates have been determined after a per- nal inspection of each of the four river basins involved. The estimates are o based on information gathered at numerous conferences with competent engi- ers and designers, held during these inspection trips. The terms set out in is report represent the considered opinion of the writer based on a six-month udy of the hydro-electric problems and of the construction of power plants in oslavia. These studies reflect the writer's belief that the designing and con- uction of the projects could be put on a more rational basis and the comple- n of the projects could be achieved within a much shorter time than it has n in the past. The field notes made after the inspection of each of the four vementioned river basins and of the Bohinjsko Jezero are attached to this re- t.

Table IV

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

Approximate Yearly Winter and Summer Export Generation

Year of Initial Delivery		Project	Average Yearly Export Generation per Project 1000 Million KWh		Total yearly export Generation 1000 Million KWh		
			Winter	Summer	Winter	Summer	Total
1.	1955	Jablanica	0.57	0.20			
2.	1955	Slovenia System	0.23	0.10	0.80	0.30	1.10
3.	1956	Zeta Run-of-River	0.50	0.10	1.30	0.40	1.70
4.	1957	Ulog	0.45	0.10			
5.	1957	Zeta First Storage	0.10	0.00	1.85	0.50	2.35
6.	1958	Glavatičevo	0.30	0.10			
7.	1958	Zeta Second Storage	0.40	0.00	2.55	0.60	3.15
8.	1959	Rama	0.60	0.10			
9.	1959	Cetina First Step	1.60	0.40	4.75	1.10	5.85
10.	1960	Trebišnjica	2.15	0.20	6.90	1.30	8.20
11	1961	Neretva Remainder	1.50	0.40	8.40	1.70	10.10

H. TRANSMISSION SYSTEM AND PROPOSED EXPORT ENERGY FLOW

The natural method of exporting energy from the Adriatic shore to Italy and Austria would be to run a high tension transmission line passing close to the energy export power plants. This transmission line should be connected with all the export plants of the Adriatic Belt. To make the proposition economic it will be advisable to use a high voltage the necessary equipment for which can be obtained without any particular difficulty and at a reasonable cost. It appears economic, considering the distance and amounts of energy involved, to go higher than 220 KV. It would probably be economic and convenient to use a 400 KV system.

The high cost of substations in such a transmission system and the tendency to make the system as reliable as possible will make it desirable to reduce the number of substations to the unavoidable minimum.

It appears that it would be most rational to provide a distribution substation in Slovenia and locate it as close as possible to the Italian and Austrian border line. The energy could be transmitted to Italy and Austria from that substation at any voltage these countries might desire at the standard 50 cycles frequency. All the transformers for energy delivery from the distribution station on, as well as switching equipment for the transmission lines going across the Yugoslav frontier could be the property of the energy receiving country. All metering of energy delivered abroad is to be done at the distribution substation.

The unified operation of the whole system of power plants and transmission lines should be governed from a single chief dispatcher's office which might be located at any point along the transmission line but preferably close to the main distribution substation. The chief dispatcher must have at his disposal the most reliable means of communications with each power house and substation, as well as with the chief dispatchers of Italy and Austria. All instructions of vital importance for the successful operation of the system are to be issued over a carrier-current telephone or by any other means available to him.

The regulation of the system will require a considerable amount of synchronous condensers capacity and other compensating equipment adequately distributed over the whole extent of the system.

It is suggested that the transmission line from Jablanica to the distribution substation in Slovenia be initially operated at 220 KV. Such an operation will prvvide the necessary training for the personnel which is to handle high tension trnasmission lines under specific conditions that will be characteristic of the Yugoslav energy export system. The 220 KV equipment is at present better standardised than the higher voltage equipment and could be obtained within a shorter time. The first transmission line could be put in operation in 1955, at the time when the Jablanica power plant is ready for the export of energy.

The next transmission line - the one to Zeta, and all the other transmission lines of the Energy Export System should be of a higher voltage. After the Zeta transmission line has been put in operation the Jablanica transmission line should be reinsulated so that the whole system be operated at the same high voltage of, probably, 400 KV.

The length, voltage and presumable initial operation dates of the ransmission lines of the system are summarised in the attached table entitled "Initial Operation Dates for Transmission Lines Connecting the Power lants and the Distribution Substation in Slovenia".

Even though the transmission lines are to run practically parallel o each other it is recommended to place them at some distance from one anther so as to eliminate the possibility of local damage extending to all the ransmission lines which would result in a total stoppage of service over the hole system. The transmission lines are to be joined together at each substation so that upon instruction of the chief dispatcher they might be operated either on a parallel basis or in segregation. This would also permit o achieve, without any interruption of energy delivery, the isolation of any ingle transmission line that may be damaged or that should be put out of serice for paintenance or repair purposes.

The maps: "Recommended System Development 1955"(Fig.1) and "Recomended System Development 1961" (Fig.2), attached to the Recommendations, how respectively the initial Jablanica transmission line and the complete ystem as recommended. The system as shown on the second map might be furer expanded in the future if it were deemed desirable to increase the vome of energy export.

The attached schematic wiring diagram "Power Scheme - Recommended ystem Development 1961" (Fig.5) summarises the high points of the electric tures of the System.

Table V

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

Initial Operation Dates for Transmission Lines Connecting the Power Plants and the Distribution Substation in Slovenia .

	Year of initial operation	End point of transmission lines	Length in km	Voltage in KV
1.	1955	Jablanica	480	220
2.	1956	Zeta	572	400
3.	1957	Jablanica reinsulated	480	400
4.	1959	Cetina I	380	400
5.	1960	Trebišnjica	530	400
6.	1961	Neretva	547	400

Total length of 400 KV transmission lines in operation between the years 1956 and 1961 :

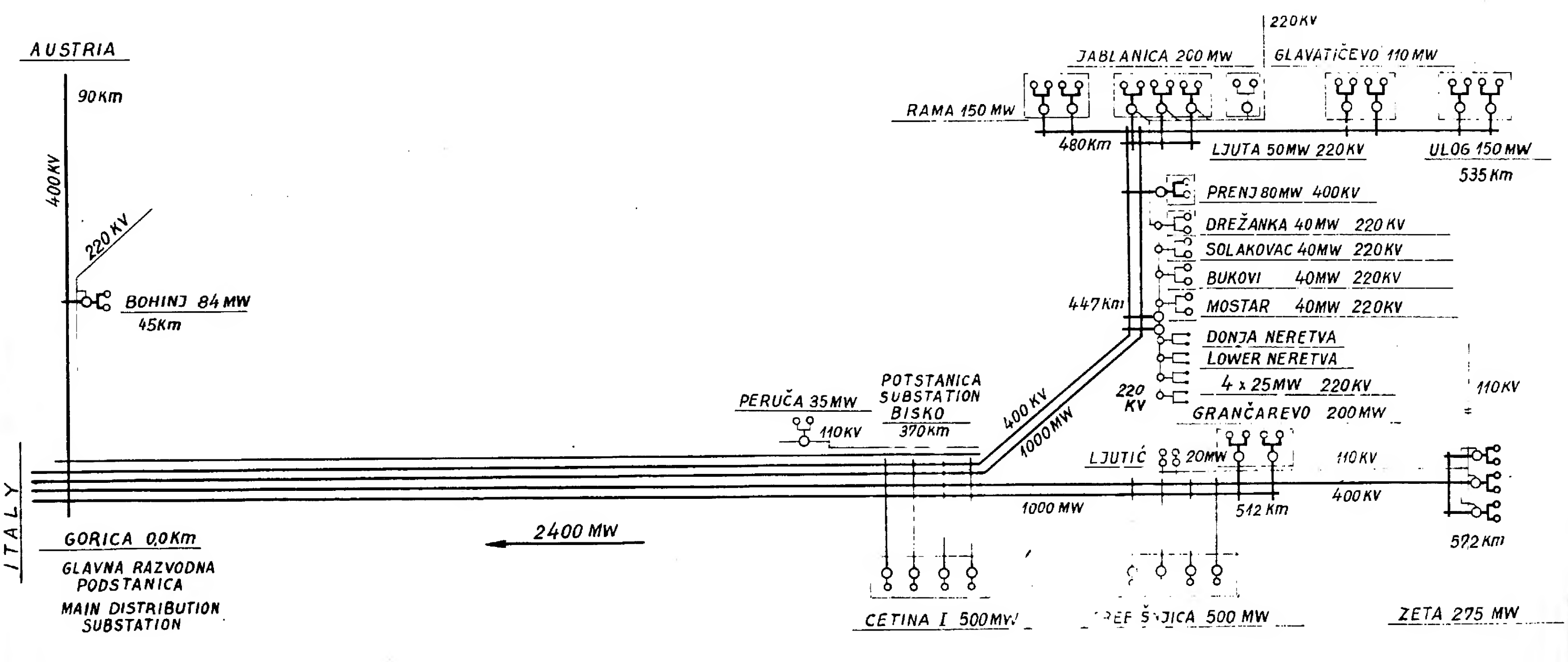
1956	-	572 km
1957	-	1052 km
1958	-	1052 km
1959	-	1432 km
1960	-	1962 km
1961	-	2509 km

Fig 5
Report by
A.V. KARPOV

IZVOZ ELEKTRIČNE ENERGIJE IZ JUGOSLAVIJE
ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

ELEKTRIČNA SHEMA – POWER SHEME

PREDLOG IZGRADNJE SISTEMA 1961
RECOMMENDED SYSTEM DEVELOPMENT 1961



Sastavio: Dr V. Šlebinger
April 1953

Approved For Release 2010/09/10 : CIA-RDP83-00423R000900250002-3

I. YEARLY DELIVERY SCHEDULES OF ENERGY EXPORTS

In signing a commercial agreement to deliver energy it is of utmost importance to the consumer to have the assurance of a definite minimum energy delivery that is to be made each month or year. Any amount of energy that could eventually be delivered above the stipulated minimum is of lesser value to the consumer. It may be difficult and in some cases even impossible to utilise such additional but uncertain amounts of energy.

Commercially that is usually reflected in the higher price paid for stipulated minimum delivery. If that price is high, heavy penalties may be imposed for failure to deliver that minimum in accordance with the agreed upon terms. The price of energy to be delivered above the stipulated minimum amount is usually lower. In some instances the difference in price may become substantial.

Keeping in mind the winter-summer difference in price it will be necessary to have as large as possible winter delivery included in the stipulated minimum amount and as small as possible summer delivery. Whenever it should prove economical, the water becoming available in summer should be accumulated in a storage reservoir and reserved for additional energy generation in winter.

From the price of energy viewpoint the amount of guaranteed high cost energy must be limited to the amount that could be delivered in winter during a low water year. The average amount of energy calculated on the basis of a few low water year deliveries and a few high water year deliveries can hardly be used as a basis for the calculation of cost and price estimates.

J. APPROXIMATE ESTIMATE OF CAPITAL COST INVOLVED

The cost estimates for a development can be prepared on a reasonable basis by studying the cost of structures already built. Analysing these data it is possible to determine which unit cost in a proposed structure must be increased and which decreased. As soon as such data and the necessary experience are available, it will be possible to determine the savings in cost and time that could be attained by better organisation and systematisation of work and also by introducing new or extending the already available mechanisation.

No cost figures are available in Yugoslavia and no standard methods of determining the cost are known there.

In preparing general estimates of cost of a proposed project no particular difficulties will be experienced in estimating the dollar cost of equipment that should be supplied from abroad. On the other hand, it does not appear possible to determine with a considerable degree of accuracy the cost in dinars of equipment, material and labour that is to be supplied locally. Under the Yugoslav financial system, where the cost is based onapplication of labour cost coefficients that may run as high as a thousand percent of the actual cost of labour and are frequently changed, no cost estimates in the accepted sense of the word can be made.

It would be of vital importance to work out a standard for the elaboration of actual cost estimates for projects with a reasonable degree of accuracy.

It is not possible o make estimates of cost for projects of such magnitude until an accepted method for the elaboration of cost estimates has been developed and until the geological structure and mechanical properties of the areas in question have been carefully determined. Such a determination would involve considerable amounts of field work. Not much work of that kind has been done so far and what has been done does not reach the required standard by a wide margin, both in respect of quality and quantity. But even after a sufficient amount of investigation has been made it will be impossible to prepare a cost estimate that would, from the point of view

of accuracy compare favourably with standard estimates if no established estimating method has been developed.

Nevertheless, it would appear necessary to make a cost study that would give if not exact estimates then at least approximate figures that could be used to establish the magnitude of the undertaking and supply some indication as to the approximate cost of producing energy.

The attempt to make a capital cost estimate could be started with a calculation of the approximate cost in dollars of the proposed energy export system.

The power plants to be comprised in this system could be categorised under low, medium and high cost plants. The Zeta plant is a low cost plant and the cost per KW capacity installed is assumed at 250 dollars for the run-of-river plant. The cost of additional installation in connection with the first and second storage reservoirs at the same plant has been assumed at 100 dollars per KW.

The Slovene plants, the Ulog and Glavatičevo plants on the upper reaches of the Neretva River and the Trebišnjica plant come under the category of medium cost plants. The cost of these plants is assumed at 275 dollars per KW.

The high cost category includes Jablanica, Rama, Cetina-First Step and the remaining plants on the Neretva River. The cost of these plants is assumed at 300 dollars per KW.

These costs should comprise the cost of a complete power plant with all the necessary structures, machinery, power houses, switchyards, transformers and the connection from the power plant to high tension transmission line substations.

The 220 KW Jablanica transmission line is estimated to cost 35,000 dollars per kilometer. This should include the tower structures and spacing so arranged that the line could be later on reinsulated for 400 KV. The above cost estimate includes all substations , high tension transformers, as well as all the necessary communication and operating equipment. The cost of reinsulation of this line from 220 to 400 KV is estimated at 20,000 dollars per kilometer.

The 400 KV transmission lines are estimated to cost about 50,000 dollars per kilometer. This figure includes, beside the transmission line proper all essential equipment , such as synchronous condensers and communication and other facilities necessary for the operation of the system.

The basic data of the system and the year by year cost of the parts of the system the construction of which is expected to be completed within each year are summarised in the attached table : Approximate Installed Capacity in MV, Length of Transmission Lines System in Kilometers and Their Equivalent Cost in Dollars.(Table VI)

The total cost of 2450 MV installed capacity in power plants and 2509 kilometers of 400 KV transmission lines is estimated at 801.65 million dollars. Two major problems arise in connection with the financing of the system. First, a large portion of the total cost will be spent in local currency, while foreign currency will be required for a smaller part of the total expenditure. Second, it would not be necessary to obtain the total sum required for the realisation of the system by means of contracting loans. When the first part of the system has been put in operation, it will be possible to finance at least a part if not the whole of the remaining development out of profits earned from selling the energy abroad.

In the absence of any data it will be necessary to develop a method of dividing the capital cost estimates into two parts. First, the equipment and services that should be supplied from abroad. The cost of this equipment and services would be estimated on the basis of current world market prices plus a margin for handling and transportation charges.

As to the second part of total expenditure, to be made in local currency, it could be estimated on the basis of actual cost incurred on similar developments in the United States and converted into dinars at the official rate of 300 dinars per dollar plus a certain percentage reflecting the actual conditions in Yugoslavia. On the basis of information received that addition should be 100%. However, making a bold assumption that very substantial savings might be achieved in the future, this additional margin might be decreased to 50%.

As indicated in the attached table Approximate Year-By-Year Requirements in Foreign and Local Currency, the cost can be divided into foreign and local currency requirements. This division has been based on

the assumption that all major equipment will be delivered from abroad and that local expenditures will include the cost of local labour and minor equipment as well as of all materials to be obtained locally. No interest payments to be made during the construction period have been included in this cost estimate. (Table VII)

The necessary amounts of foreign and local currency have been arranged on a year-by-year basis. There is, therefore, a distinction between the amounts of yearly expenditures as indicated in this table and in the preceding one.

Table VI

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

Approximate installed capacity in MW, length of transmission system in km, and their equivalent cost in dollars.

			Equivalent cost		
Project	Capacity MW	Length km	per KW capacity dollars	per km of line dollars	Total cost million dollars
Including 1955					
Jablanica	200	480	300	35,000	
Slovenia System	100		275		104,35
Including 1956					
Zeta no storage	150	572	250	50,000	66.10
Including 1957					
Ulog	150		275	50,000	
Zeta First storage	75		100		
Reinsulation Jablanica line		480		20,000	58.30
Including 1958					
Glavatičevo	100		275		
Zeta Second storage	75		100		35.00
Including 1959					
Rama	150		300		
Cetina First step	450	380	300	50,000	199.00
Including 1960					
Trebišnjica	600	530	275	50,000	191.50
Including 1961					
Neretva Remainder	400	547	300	50,000	147.40
				Total :	801.65

Total installed capacity - 2450 MW
Total length of 400 KV transmission lines - 2509 km.

Table VII

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

Capital Cost - Approximate Year-by-Year Requirements in
Foreign and Local Currencies

Y e a r	Foreign Currency Million Dollars	Local Currency Million Dinars
1953	60.0	39 000
1954	60.5	43 000
1955	47.5	33 500
1956	37.2	26 500
1957	35.5	26 000
1958	29.0	21 500
1959	24.5	18 500
1960	15.5	7 500
1961	5.0	3 500
T o t a l :	314.7	219 000

K. FINANCIAL ARRANGEMENTS

The Electric Energy Export System of Yugoslavia will require the in- tment of a large amount of money. The foreign and local currency require- ts given in Table VII are obviously of such magnitude that Yugoslavia could afford to invest so much money on her own in a comparatively short period of e years.

It is possible that the financial conditions of the country will permit expenditure of a substantial part of the sum required in local currency. The eign currency must necessarily be provided by means of an international loan.

The present world conditions are reasonably favourable for the conclu- n of financial arrangements that would permit the export of energy from Yugo- via. It would be preferable to try to obtain a straight loan under the most ourable conditions possible rather than to ask for a grant. Thus a purely fi- cial transaction would be involved. In future, the world financial conditions no longer be so favourable as they are at present and if the matter is delay- it may be reflected in increased difficulty to obtain a loan and in harder ms.

The loan situation will be all the more favourable due to the fact that system will be developed gradually. It would therefore be possible to invest ing the partial operation of the first stages of the system a large portion or n all the income of the system in order to finance the remaining stages.

Under the present conditions it may be difficult to obtain the whole of necessary foreign loan through a direct banking operation. Some parts might sibly be obtained from foreign countries in other forms, as for instance in the pe of machinery, equipment and services. These methods of obtaining foreign rrency have considerable disadvantages and should be used only if no direct loan n be obtained. In all probability, a combination of several methods of obtain- a loan will be the ultimate outcome of the financial negotiations. If such a plicated financing system must be used it is particularly necessary to have a r understanding of what can be accomplished by the best method, that of a ect loan. Any other loan combination must be analysed and compared with the di- t loan method so that a picture can be obtained of the relative advantages and advantages of the other loan methods.

In order to clarify the financial possibilities two variants of finan- rrangements have been analysed;

Variant "A" is based on the assumption that during the years 1955-1961 amounts of foreign currency will be obtained from the operation of the and reinvested in it. It is assumed that all local currency requirements be covered by Yugoslavia. These assumptions are summarised in Table The selling price of energy being unknown, the reinvestment charges are d as charges in Mils (one tenth of one cent or one thousandth of one dol- nd as charges in Dinars per KWh to be generated in the system plants dur- average water year.

Variant "B" is summarised in Table XIV. The reivestment charges in n currency are much smaller but reinvestments are assumed in local cy too.

As a result, the foreign currency loan in Variant "B" is higher than in t "A" but the original local currency investment is smaller in Variant "B" can be seen from the following table:

	Variant "A"	Variant "B"
riginal Loan		
Million Dollars	163.40	207.50
Million Dinars	219 000	167 000
einvestment		
Million Dollars	151.30	107.20
Million Dinars	--	51 900
otal Investment		
Million Dollars	314.70	314.70
Million Dinars	219 000	219 000

Both these variants are analysed under the following assumptions:

1. Interest charges on the foreign loan are 4.5%.

2. Interest payments on the foreign loan are deferred until 1958 for Variant "A" and until 1959 for Variant "B".

3. The loan will be repaid in 25 years beginning from 1958 for Variant "A" and 1959 for Variant "B".

4. Interest charges on foreign currency reinvestment of the system income are taken at 3%. The payment of interest on reinvestment is deferred until 1959.

5. The reinvestment in foreign currency will be repaid in 25 years, the repayment beginning in 1962 for Variant "A" and in 1961 for Variant "B"..

6. The local currency investment interest is 3%. The payment of the interest is deferred until 1962 for both variants.

7. The local currency investment and reinvestment will be repaid in 25 years beginning with 1961.

Tables IX to XIII inclusive give the foreign and local currency s for Variant "A" over the whole period until all the investment is . Tables XV to XIX inclusive give the same charges for Variant "B" .

Variant "A" involves a smaller loan and the financial charges are, ore, smaller. Table XX gives a comparison of cost of foreign currency As can be seen from this Table, the Variant "B" financing scheme will e an excess payment of 44 million dollars until the time when the origin- ns have been repaid.

Insofar as local currency is concerned it will be necessary for Yu- via to invest 219 000 Million Dinars in nine years under Variant "A" and 167 000 Million Dinars in seven years under Variant "B". The financial tions of the country permitting, it would seem advisable to invest the ional 52 000 Million Dinars in local currency in order to reduce the ial charges in foreign currency by 44 Million Dollars.

Financial arrangements under either Variant "A" or "B" will not only ossible the construction and owning of a large energy export system at a

comparatively small expense for Yugoslavia , but also produce a stabilising effect on the international value of the Yugoslav currency. This big system will be built without it being necessary to expend Yugoslav currency on the acquisition of foreign exchange. To the contrary, once the system is completed and put in operation it will earn foreign exchange. Part of this foreign exchange must be used to buy Yugoslav currency in order to cover that part of expenditure that must be made in local currency. This will, of course, tend to improve the financial standing of the country.

Table VIII

FOREIGN AND LOCAL CURRENCY LOAN AND REINVESTMENT REQUIREMENTS
VARIANT "A"

Reinvestment: Foreign currency - 15.0 mils or less per generated KWh
Local currency - no reinvestment

Foreign Currency -

Year	Energy Generated 1000 Million KWh	Reinvestment Mils per KWh	Reinvestment Million Dollars	Loan Million Dollars	Total Million Dollars
1953				60.00	60.00
1954				60.50	60.50
1955	1.10	15.0	16.50	31.00	47.50
1956	1.70	15.0	25.60	11.60	37.20
1957	2.35	15.0	35.20	0.30	35.50
1958	3.15	9.2	29.00		29.00
1959	5.35	4.6	24.50		24.50
1960	8.20	1.9	15.50		15.50
1961	10.10	0.5	5.00		5.00
			151.30	163.40	314.70

Local Currency -

Year	Energy Generated 1000 Million KWh	Reinvestment Dinars per KWh	Reinvestment Million Dinars	Loan Million Dinars	Total Million Dinars
1953				39 000	39 000
1954				43 000	43 000
1955	1.10			33 500	33 500
1956	1.70			26 500	26 500
1957	2.35			26 000	26 000
1958	3.15			21 500	21 500
1959	5.35			18 500	18 500
1960	8.20			7 500	7 500
1961	10.10			3 500	3 500
				219 000	219 000

Table IX

FOREIGN CURRENCY LOAN - VARIANT "A"

Loan Charges

Year	Loan Yearly Installment	Loan Plus 4.5% Accumulated Interest	Loan Repayable	Interest on Loan 4.5 %	Repayment of Loan 25 Years	Total Loan Charges
	Million Dollars					
1953	60.00	-	-	-	-	-
1954	60.50	62.70				
1955	31.00	123.20				
1956	11.60	159.70				
1957	0.30	178.60				
1958		186.90	186.900		7.476	7.476
1959			179.424	8.390	7.476	15.866
1960			171.948	8.060	7.476	15.476
1961			164.472	7.740	7.476	15.216
1962			156.996	7.410	7.476	14.886
1963			149.520	7.070	7.476	14.546
1964			142.044	6.740	7.476	14.216
1965			134.568	6.400	7.476	13.876
1966			127.092	6.050	7.476	13.526
1967			119.616	5.720	7.476	13.196
1968			112.140	5.380	7.476	12.856
1969			104.664	5.050	7.476	12.526
1970			97.188	4.610	7.476	12.086
1971			89.712	4.380	7.476	11.856
1972			82.236	4.040	7.476	11.516
1973			74.760	3.700	7.476	11.176
1974			67.284	3.360	7.476	10.836
1975			59.808	3.030	7.476	10.506
1976			52.332	2.690	7.476	10.166
1977			44.856	2.350	7.476	9.826
1978			37.380	2.020	7.476	9.496
1979			29.904	1.680	7.476	9.156
1980			22.428	1.340	7.476	8.816
1981			14.952	1.010	7.476	8.486
1982			7.476	0.660	7.476	8.136
1983			-	0.340	-	0.340
Total :	163.40			109.220	186.900	296.120

Table X

FOREIGN CURRENCY REINVESTMENT - VARIANT "A"

Reinvestment Charges

Year	Million Dollars						
	Reinvestment Installment	Accumulating Interest 3 %	Reinvestment plus Accumulated Interest	Reinvestment Repayable	Interest Payment 3 %	Reinvestment Repayment 25 Years	Total Reinvestment Charge
1953							
1954							
1955	16.50	-	16.500	-	-	-	-
1956	25.60	0.495	42.595	-	-	-	-
1957	35.20	1.280	79.075	-	-	-	-
1958	29.00	2.390	110.465	110.465	-	-	-
1959	24.50	3.320	-	134.965	3.320	-	3.320
1960	15.50	-	-	150.465	4.045	-	4.045
1961	5.00	-	-	155.465	4.530	-	4.530
1962				155.465	4.664	6.219	10.883
1963				149.246	4.664	6.219	10.883
1964				143.027	4.480	6.219	10.699
1965				136.808	4.300	6.219	10.519
1966				130.589	4.110	6.219	10.329
1967				124.370	3.920	6.219	10.139
1968				118.151	3.730	6.219	9.949
1969				111.932	3.550	6.219	9.769
1970				105.713	3.340	6.219	9.559
1971				99.494	3.170	6.219	9.389
1972				93.275	2.990	6.219	9.209
1973				87.056	2.800	6.219	9.019
1974				80.837	2.620	6.219	8.839
1975				74.618	2.430	6.219	8.649
1976				68.399	2.240	6.219	8.459
1977				62.180	2.050	6.219	8.269
1978				55.961	1.870	6.219	8.089
1979				49.742	1.680	6.219	7.899
1980				43.523	1.480	6.219	7.699
1981				37.304	1.310	6.219	7.529
1982				31.085	1.120	6.219	7.339
1983				24.866	0.930	6.219	7.149
1984				18.647	0.750	6.219	6.969
1985				12.428	0.550	6.219	6.769
1986				6.219	0.374	6.219	6.593
1987				-	0.187	-	0.187

Table XI

FOREIGN CURRENCY - VARIANT "A"

Yearly Expenditures - Loan Charges, Reinvestment Charges, Reinvestment

Year	Loan Charge	Reinvestment Charge	Total Loan and Reinvestment Charge	Reinvestment Yearly Instalment	Total Charge
	Million Dollars				
1953					
1954					
1955	-	-	-	16.50	16.50
1956	-	-	-	25.60	25.60
1957	-	-	-	35.20	35.20
1958	7.476	-	7.476	29.00	36.48
1959	15.866	3.320	19.186	24.50	43.67
1960	15.476	4.045	19.521	15.50	35.02
1961	15.216	4.530	19.746	5.00	24.75
1962	14.886	10.883	25.769	-	25.77
1963	14.546	10.883	25.429	-	25.43
1964	14.216	10.699	24.915	-	24.92
1965	13.876	10.519	24.395	-	24.40
1966	13.526	10.329	23.855	-	23.86
1967	13.196	10.139	23.335	-	23.34
1968	12.856	9.949	22.805	-	22.81
1969	12.526	9.769	22.295	-	22.30
1970	12.086	9.559	21.645	-	21.65
1971	11.856	9.389	21.245	-	21.25
1972	11.516	9.209	20.725	-	20.73
1973	11.176	9.019	20.195	-	20.20
1974	10.836	8.839	19.675	-	19.68
1975	10.506	8.649	19.155	-	19.16
1976	10.166	8.459	18.625	-	18.63
1977	9.826	8.269	18.095	-	18.10
1978	9.496	8.089	17.585	-	17.59
1979	9.156	7.899	17.055	-	17.06
1980	8.816	7.699	16.515	-	16.52
1981	8.486	7.529	16.015	-	16.02
1982	8.136	7.339	15.475	-	15.48
1983	0.340	7.149	7.489	-	7.49
1984	-	6.969	6.969	-	6.97
1985	-	6.769	6.769	-	6.77
1986	-	6.593	6.593	-	6.59
1987	-	0.187	0.187	-	0.19

Table XII

LOCAL CURRENCY - VARIANT "A"

Yearly Capital Charges

Year	Investment Installment	Investment Plus 3% Accumulated Interest	Investment Repayable	Interest Payment 3%	Investment Repayment 25 years	Total Capital Charge
	M i l l i o n			D i n a r s		
1953	39 000	39 000				
1954	43 000	83 170				
1955	33 500	119 170				
1956	26 500	149 250				
1957	26 000	179 730				
1958	21 500	206 620				
1959	18 500	231 340				
1960	7 500	245 790				
1961	3 500	256 650	256 650		10 266	10 266
1962			246 384	7 710	10 266	17 976
1963			236 118	7 390	10 266	17 656
1964			225 852	7 100	10 266	17 366
1965			215 586	6 760	10 266	17 026
1966			205 320	6 460	10 266	16 726
1967			195 054	6 160	10 266	16 426
1968			184 788	5 860	10 266	16 126
1969			174 522	5 550	10 266	15 816
1970			164 256	5 240	10 266	15 506
1971			153 990	4 940	10 266	15 206
1972			143 724	4 620	10 266	14 886
1973			133 458	4 310	10 266	14 576
1974			123 192	4 010	10 266	14 276
1975			112 926	3 700	10 266	13 966
1976			102 660	3 390	10 266	13 656
1977			92 394	3 080	10 266	13 346
1978			82 128	2 770	10 266	13 036
1979			71 862	2 470	10 266	12 736
1980			61 596	2 160	10 266	12 426
1981			51 330	1 850	10 266	12 116
1982			41 064	1 540	10 266	11 806
1983			30 798	1 220	10 266	11 486
1984			20 532	920	10 266	11 186
1985			10 266	616	10 266	10 882
1986				305		305
	219 000			100 131	256 650	356 781

Table XIII

FOREIGN AND LOCAL CURRENCIES - VARIANT "A"

Capital Charges

Yearly Expenditures

Year	Foreign Currency Payment Million Dollars	Local Currency Payment Million Dinars	Energy Generated 1000 Million KWh	Foreign Currency Payment Mils per KWh	Local Currency Payment Dinars per KWh
1953					
1954					
1955	16.50		1.10	15.00	
1956	25.60		1.70	15.00	
1957	35.20		2.35	15.00	
1958	36.48		3.15	11.60	
1959	43.67		5.35	8.15	
1960	35.02		8.20	4.30	
1961	24.75	10 266	10.10	2.45	1.02
1962	25.77	17 976	10.10	2.55	1.78
1963	25.43	19 956	10.10	2.52	1.75
1964	24.92	17 366	10.10	2.47	1.72
1965	24.40	17 026	10.10	2.42	1.69
1966	23.86	16 726	10.10	2.37	1.66
1967	23.34	16 426	10.10	2.31	1.63
1968	22.81	16 126	10.10	2.26	1.60
1969	22.30	15 816	10.10	2.21	1.57
1970	21.65	15 506	10.10	2.14	1.54
1971	21.25	15 206	10.10	2.11	1.51
1972	20.73	14 886	10.10	2.05	1.47
1973	20.20	14 576	10.10	2.00	1.44
1974	19.69	14 276	10.10	1.95	1,41
1975	19.16	13 966	10.10	1.90	1.37
1976	18.63	13 566	10.10	1.85	1.35
1977	18.10	13 346	10.10	1.79	1.32
1978	17.59	13 036	10.10	1.74	1.29
1979	17.06	12 736	10.10	1.69	1.26
1980	16.52	12 426	10.10	1.64	1.23
1981	16.02	12 116	10.10	1.59	1.20
1982	15.48	11 806	10.10	1.52	1.17
1983	7.49	11 486	10.10	0.74	1.14
1984	6.97	11 186	10.10	0.69	1.10
1985	6.77	10 882	10.10	0.67	1.08
1986	6.59	305	10.10	0.65	0.03
1987	0.19		10.10	0.02	

Table XIV

FOREIGN AND LOCAL CURRENCY LOAN AND REINVESTMENT REQUIREMENTS
VARIANT "B"

Reinvestment: Foreign currency - 7.5 mils or less per generated KWh
Local currency - 3 Dinars or less per generated KWh

Foreign Currency -

Year	Energy Generated 1000 Million KWh	Reinvestment		Loan Million Dollars	Total Million Dollars
		Mils per KWh	Million Dollars		
1953				60.00	60.00
1954				60.50	60.50
1955	1.10	7.5	8.25	39.25	47.50
1956	1.70	7.5	12.75	24.45	37.20
1957	2.35	7.5	17.60	17.90	35.50
1958	3.15	7.5	23.60	5.40	29.00
1959	5.35	4.6	24.50		24.50
1960	8.20	1.9	15.50		15.50
1961	10.10	0.5	5.00		5.00
			107.20	207.50	314.70

Local Currency -

Year	Energy Generated 1000 Million KWh	Reinvestment		Loan Million Dinars	Total Million Dinars
		Dinars per KWh	Million Dinars		
1953				39 000	39 000
1954				43 000	43 000
1955	1.10	3	3 300	30 200	33 500
1956	1.70	3	5 100	21 400	26 500
1957	2.35	3	7 000	19 000	26 000
1958	3.15	3	9 500	12 000	21 500
1959	5.35	3	16 000	2 500	18 500
1960	8.20	0.9	7 500		7 500
1961	10.10		3 500		3 500
			51 900	167 100	219 000

Table XV

FOREIGN CURRENCY LOAN - VARIANT "B"

Loan Charges

Year	Million Dollars					
	Loan Yearly Install-ment	Loan Plus 4.5% Accu-mulated Interest	Loan Repayable	Interest on Loan 4.5 %	Repayment of Loan 25 Years	Total Loan Charges
1953	60.00	-	-	-	-	-
1954	60.50	62.70				
1955	39.25	123.20				
1956	24.45	168.00				
1957	17.90	200.01				
1958	5.40	226.91				
1959		242.53	242.53	-	9.702	9.70
1960			232.828	10.90	9.702	20.60
1961			223.126	10.50	9.702	20.20
1962			213.424	10.10	9.702	19.80
1963			203.722	9.60	9.702	19.30
1964			194.020	9.15	9.702	18.85
1965			184.318	8.75	9.702	18.45
1966			174.619	8.30	9.702	18.00
1967			164.914	7.85	9.702	17.55
1968			155.212	7.44	9.702	17.14
1969			143.510	7.00	9.702	16.70
1970			135.808	6.56	9.702	16.26
1971			126.106	6.11	9.702	15.81
1972			116.404	5.65	9.702	15.35
1973			106.702	5.25	9.702	14.95
1974			97.000	4.78	9.702	14.48
1975			87.298	4.36	9.702	14.06
1976			77.596	3.93	9.702	13.63
1977			61.884	3.93	9.702	13.12
1978			58.192	3.06	9.702	12.76
1979			48.490	2.62	9.702	12.32
1980			38.806	2.18	9.702	11.88
1981			29.204	1.75	9.702	11.45
1982			19.402	1.32	9.702	11.02
1983			9.700	0.88	9.702	10.58
1984				0.44		0.44
Total	207.50				242.53	

Table XVI

FOREIGN CURRENCY REINVESTMENT - VARIANT "B"

Reinvestment Charges

Year	Reinvestment Installment	Reinvestment Plus 3% accum. interest	Reinvestment Repayable	Interest Payment	Reinvestment Repayment	Total Repayment Charge
	Million Dollars					
1953						
1954						
1955	8.25	8.25				
1956	12.75	21.25				
1957	17.60	39.49				
1958	23.60	64.28	64.200			
1959	24.30		88.580	1.93		1.93
1960	15.50		104.580	2.66		2.66
1961	5.00		109.080	3.14	4.364	7.50
1962			104.716	3.28	4.364	7.64
1963			100.352	3.15	4.364	7.51
1964			95.988	3.01	4.364	7.37
1965			91.624	2.88	4.364	7.22
1966			87.220	2.75	4.364	7.11
1967			82.856	2.62	4.364	6.98
1968			78.492	2.46	4.364	6.82
1969			74.128	2.35	4.364	6.71
1970			69.764	2.23	4.364	6.59
1971			65.400	2.09	4.364	6.45
1972			61.034	1.96	4.364	6.32
1973			56.570	1.83	4.364	6.19
1974			52.306	1.70	4.364	6.06
1975			47.942	1.57	4.364	5.93
1976			43.578	1.44	4.364	5.80
1977			39.214	1.31	4.364	5.67
1978			34.850	1.18	4.364	5.54
1979			30.486	1.05	4.364	5.41
1980			26.122	0.91	4.364	5.27
1981			21.758	0.78	4.364	5.14
1982			17.394	0.65	4.364	5.01
1983			13.030	0.52	4.364	4.88
1984			8.660	0.39	4.364	4.75
1985			4.302	0.26	4.364	4.62
1986				0.13	-	0.13
	107.20				109.080	

FOREIGN CURRENCY - VARIANT "B"

Yearly Expenditures : Loan Charges, Reinvestment Charges, Reinvestment

Year	Loan Charge	Reinvestment Charge	Total Loan and Reinvest. Charge	Reinvest. Yearly Installment	Total Payment
	Payment in Million Dollars				
1953					
1954					
1955				8.25	8.25
1956				12.75	12.75
1957				17.60	17.60
1958				23.60	23.60
1959	9.70	1.93	16.63	24.50	41.13
1960	20.60	2.66	23.26	15.50	38.86
1961	20.20	7.50	27.70	5.00	32.70
1962	19.80	7.64	27.44	-	27.44
1963	19.30	7.51	26.81	-	26.81
1964	18.85	7.37	26.22	-	26.22
1965	18.45	7.22	25.67	-	25.67
1966	18.00	7.11	25.11	-	25.11
1967	17.55	6.98	24.53	-	24.53
1968	17.14	6.82	23.96	-	23.96
1969	16.70	6.71	23.41	-	23.41
1970	16.26	6.59	22.85	-	22.85
1971	15.81	6.45	22.26	-	22.26
1972	15.35	6.32	21.67	-	21.67
1973	14.95	6.19	21.04	-	21.04
1974	14.48	6.06	20.54	-	20.54
1975	14.06	5.93	19.99	-	19.99
1976	13.63	5.80	19.43	-	19.43
1977	13.12	5.67	18.89	-	18.89
1978	12.76	5.54	18.30	-	18.30
1979	12.32	5.41	17.73	-	17.73
1980	11.88	5.27	17.15	-	17.15
1981	11.45	5.14	16.59	-	16.59
1982	11.02	5.01	16.03	-	16.03
1983	10.58	4.88	15.46	-	15.46
1984	0.47	4.75	5.22	-	5.22
1985	-	4.62	4.62	-	4.62
1986	-	0.13	0.13	-	0.13

Table XVIII

LOCAL CURRENCY - VARIANT "B"

Yearly Capital Charges

Year	Million Dinars						
	Investment installment	Rein-vest-ment	Total install-ment	Investment plus 3% ac-cumulated interest repayable	Interest payment 3%	Investment repayment 25 years	Total capital charges
1953	39 000		39 000	39 000			
1954	43 000		43 000	83 170			
1955	30 200	3 300	33 500	119 170			
1956	21 400	5 100	26 500	149 250			
1957	19 000	7 000	26 000	179 730			
1958	12 000	9 500	21 500	206 620			
1959	2 500	16 000	18 500	231 340			
1960		7 500	7 500	245 790			
1961		3 500	3 500	256 650		10 266	10 266
1962				246 384	7 710	10 266	17 976
1963				236 118	7 390	10 266	17 656
1964				225 852	7 100	10 266	17 366
1965				215 586	6 760	10 266	17 026
1966				205 320	6 460	10 266	16 726
1967				195 054	6 160	10 266	16 426
1968				184 788	5 860	10 266	16 126
1969				174 522	5 550	10 266	15 816
1970				164 256	5 240	10 266	15 506
1971				153 990	4 940	10 266	15 206
1972				143 724	4 620	10 266	14 886
1973				133 458	4 310	10 266	14 576
1974				123 192	4 010	10 266	14 276
1975				112 926	3 700	10 266	13 966
1976				102 660	3 390	10 266	13 656
1977				92 394	3 080	10 266	13 346
1978				82 128	2 770	10 266	13 036
1979				71 862	2 470	10 266	12 736
1980				61 596	2 160	10 266	12 426
1981				51 330	1 850	10 266	12 716
1982				41 064	1 540	10 266	11 806
1983				30 798	1 220	10 266	11 486
1984				20 532	920	10 266	11 186
1985				10 266	616	10 266	10 882
1986					305		305
					100 131	256 650	356 781

Table XIX

FOREIGN AND LOCAL CURRENCIES - VARIANT "B"

Capital Charges

Yearly Expenditures

ar	Foreign currency payment Million Dollars	Local currency payment Million Dinars	Energy generated 1000 million KWh	Foreign currency payment Mils per KWh	Local currency payment Dinars per KWh
953					
954					
955	8.25		1.10	7.50	
956	12.75		1.70	7.50	
957	17.60		2.35	7.50	
958	23.60		3.15	7.50	
959	41.13		5.35	7.69	
960	38.86		8.20	4.72	
961	32.70	10 266	10.10	3.26	1.02
962	27.44	17 976	10.10	2.82	1.78
963	26.81	17 656	10.10	2.66	1.75
964	26.22	17 366	10.10	2.60	1.72
965	25.67	17 026	10.10	2.54	1.69
966	25.11	16 726	10.10	2.49	1.66
[illegible]	24.53	16 426	10.10	2.43	1.63
	23.96	16 126	10.10	2.37	1.60
[illegible]	23.41	15 816	10.10	2.32	1.57
970	22.85	15 506	10.10	2.26	1.54
971	22.26	15 206	10.10	2.21	1.51
972	21.67	14 886	10.10	2.14	1.47
973	21.04	14 576	10.10	2.08	1.44
974	20.54	14 276	10.10	2.03	1.41
975	20.99	13 966	10.10	1.98	1.37
976	19.43	13 656	10.10	1.92	1.35
977	18.89	13 346	10.10	1.87	1.32
978	18.30	13 036	10.10	1.81	1.29
979	17.73	12 736	10.10	1.75	1.26
980	17.15	12 426	10.10	1.70	1.23
981	16.59	12 116	10.10	1.64	1.20
982	16.03	11 806	10.10	1.59	1.17
983	15.46	11 486	10.10	1.56	1.14
984	5.22	11 186	10.10	0.52	1.10
985	4.62	10 882	10.10	0.46	1.08
986	0.13	305	10.10	0.01	0.03

COMPARISON OF COST OF FOREIGN CURRENCY LOANS

VARIANTS "A" and "B"

Million Dollars

Loan Installments

	Variant "A"	Variant "B"
1953	60.00	60.00
1954	60.50	60.50
1955	31.00	39.25
1956	11.60	24.45
1957	0.30	17.90
1958		5.40
1959		
1960		
1961		
Total Original Loan	163.40	207.50
Accumulated interest 4.5%	23.50	35.03
Repayable:		
Loan	186.90	242.53
4.5% interest during loan repayment	109.22	141.91
Total Repayment	296.12	384.40
Less Original Loan	163.40	207.50
Loan Charges	132.72	176.90
Charge Variant "A"		132.72
Foreign Loan Overcharge - Variant "B" over Variant "A"		44.18

L. APPROXIMATE ESTIMATE OF COST OF EXPORTED ENERGY

The cost of energy should be so estimated as to provide for the meeting of all an ial obligations during the operation of the system and for keeping the system in st class condition throughout its life. All the direct expenses of operation of the tem must obviously be covered as well.

It is necessary to know the cost of energy before the selling price that must ch rged to make the operation of the system profitable can be determined. The cost energy must be based on the amount of energy that can be supplied during low water rs These amounts of energy will be the ones which Yugoslavia can guaranty to de-er and for which, if most of the energy is delivered during the winter season, Yugo-via can expect to obtain a high price. In the absence of any reliable information h respect to the yearly variation of water flow, the ratio between the average and imum amount of energy that could be delivered can only be assumed. Considering the e istribution of energy sources in the system it has been assumed that the varia-n in energy generation from year to year will be less accentuated in a system as hole, that it could be expected in the case of an individual power plant.

On the basis of these considerations the assumption was made that the amount energy exported during a low water year will be equal to 75% of that generated by the r lants of the system during an average year. This 25% reduction should also cover tr nsmission lines losses.

All the cost figures are based on the assumption that no taxes, either local nternational, will be paid during the construction and operation of the system. If t xes are imposed, the cost of the system and the cost of energy must be increased ordingly.

The part of the cost of energy and of the capital cost in foreign currencies t kept separated from that in local currencies. It does not seem advisable to empt converting the foreign currency,or vice versa, until such time when the world ancial conditions become more stable.

The cost of energy generation and of its transmission to the main distribution station in Gorica has been divided into three major items.

1. Capital Cost, which forms the largest portion of the total energy cost;
2. Amortization,which forms the second largest item of the total energy cost;
3. Operation Expenses, which form the smallest item of the total energy cost.

1. Capital Cost

The capital charges have been estimated and given in Table XIII for Va-nt "A" and XIX for Variant "B". In determining the cost of energy the total ount of money invested must be considered regardless of whether the money has n obtained from foreign loans or invested by Yugoslavia either out of the system's ome or from other sources. In estimating the capital charges a somewhat unortho- attitude has been taken in adding the reinvestment in foreign and local curren-s during the construction period directly to the capital charges. It is believed t the conditions under which the system is being created justify such an atti-e . At the same time, the high cost of foreign currency (4.5%) is not applied the foreign currency reinvestments which are assumed to carry an interest of 3% e same as the local currency.

2. Amortization

The ordinary maintenance of the system should be taken care of as an ordinary ation function and the expenses of such maintenance should be included in the ope-tion expenses. No matter how well the system is operated and maintained there al-ys will be normal wear and a gradual deterioration of the elements of the system. is, therefore, necessary to provide a reserve fund (amortization fund) that could used to replace parts of equipment and of the system that have been worn out or must be replaced for any other reasons. If such a policy is followed the system uld be always in a first class condition or have an amortization fund of sufficient ze available so that all elements of the system that need replacement might be re-aced. The expenses of creating an amortization fund must be considered as a normal eration expense.

The capital charges stop after the loans have been repaid. The amortization rges are intended to keep the system throughout its life in the same first class ndition as when it was originally built. All equipment and all parts of the system t are worn out to such an extent that they cannot be taken care of by regular main-nance, must be replaced in parts or in full. The amortization charge is, therefore, running charge which must be set aside to make possible large replacement expendi-res as long as the system is being operated. It may become necessary to revise ortization charges from time to time in order to follow the trends in replacement t. In nearly all instances such a revision will result in an increase of amortiza-n charges and consequently in an increase of the cost of energy.

The amortization has been estimated on the basis of an average 30 years

ife of the system. At an interest rate of 3% the annual amortization charge would ount to 2.1% of the original cost of the system. A more exact estimate of amortition charges could be made only when a more detailed cost estimate becomes avail-...

3. Operation Expenses

These expenses must be sufficient to cover salaries of all personnel employ- by the system in whatever capacity and to pay for regular maintenance , materials, are parts and so on.

The direct operation cost of the system has been divided into the cost of wer plant operation and transmission line operation.

The power plant operation cost should cover the operation of the power plants oper as well as the upkeep and operation of dams, tunnels, canals and similar other rts of the system.

The transmission line operation cost should cover the operation and upkeep transmission lines, substations, high tension transformers, switching and protective uipment, as well as the maintenance and operation expenses of the dispatching offices d communication facilities.

On the basis of some studies in this matter it was assumed that the cost of wer plants operation per KW of installed power plant capacity will be equal to 0.4 llars in foreign currency plus 720 Dinars in local currency.

The cost of transmission line operation has been estimated as 1 % of the transm... lines capital cost in Dollars plus 1% of the capital cost in Dinars.

The costs arrived at in such a way can be considered as an approximation only. is, however, believed that the project could be constructed at a cost close to the proximate estimates and the cost of energy will not differ greatly from the estimated st.

*

Table XXI gives an estimate of the cost of energy to be exported during the nter season of 1961-62 on the assumption that by that time the recommended system ll have been built and put in full operation.

Table XXII gives, in congested form, the elements of cost and the total cost energy to be exported during the years 1955 to 1961 when the system will be under nstruction and the energy will be delivered in gradually increasing amounts.

Table XXIII has been computed on the basis of the estimated capital charges ...en in Tables XIII and XIX and of the operation costs given in Table XXII.

This table gives the cost of energy exported from 1955 to 1987 within which ...d the loans and reinvestments are to be repaid. After 1987 the cost of exported ...ergy should include direct operation cost and amortisation charges only. The table ... based on the assumption of low water years. During average and high water years ...e cost of exportable energy may become lower, if the energy importing countries are ...le to accept such additional energy.

A study of the table will show that due to large reinvestments of foreign ...rency the cost of energy during the construction period 1955-1959 will be high in ...e case of Variant "A". During the same period it will be lower in the case of Va-...nt "B". After 1959, the cost of exportable energy will be lower for Variant "A" ...n for Variant "B". The difference in the cost of energy during the years succeed-...g the year 1959 corresponds to the 44 Million Dollar foreign loan increase for Va-...iant "B" over Variant "A", that was shown in Table XX.

In studying the cost and advantages of Variant "A" it may be found advisable ... Yugoslavia, as well as by the countries importing energy, to charge and/or accept ... increased selling price for energy exported during the construction period and to ...duce the price after the system has been completed. Such an arrangement may be ...ry helpful in making possible the building of the system and putting it speedily in ...eration.

In determining the selling price of energy , consideration must be given to ...e possibility that during some periods of time the consuming countries may not be ...le to accept all the energy offered by the system. Some provisions must be made to ...ver the financial losses that may occur in such an emergency.

Considering the present and future conditions it will be of distinct advan-...ge to negotiate a contract in which the cost of delivered winter energy is many times ...gher than the cost od delivered summer energy.

Table XXI

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

Operation Cost
Year 1961-1962

Installed Power Plants Capacity - 2450 KW
Length of 400 KV Transmission Lines - 2509 km

	Foreign Expenditures Dollars	Local Expenditures Million Dinars
Power Plants Operation		
2 450 000 KW at 40 cents	980 000	
at 720 Dinars		1 760
Transmission Lines Operation		
1% of 38.50 million Dollars	385 000	
1% of 40 000 million Dinars		400
Amortization - 30 years		
2.1% of 314.70 million Dollars	6 510 000	
2.1% of 219 000 million Dinars		4 600
	7 875 000	6 760

Assuming 75% average generation to be delivered in a low water year
75% of 10.10 - 1000 million KWh equals 7.57 - 1000 million KWh

Capital Charges 1961 Variant "A"

$\frac{2.45}{0.75}$ = 3.26 Mils per KWh plus $\frac{1.02}{0.75}$ = 1.36 Dinars per KWh

Capital Charges 1961 Variant "B"

$\frac{3.26}{0.75}$ = 4.35 Mils per KWh plus $\frac{1.02}{0.75}$ = 1.36 Dinars per KWh

Variant "A" 1961-1962

	Foreign Currency		Local Currency
Capital Charges	$ 3.26 Mils	plus	1.36 Dinars per KWh
Operation Charges 7 875 000 Dollars	1.04 Mils	"	
6 760 million Dinars			0.89 Dinars per KWh
Total per KWh	4.30 Mils	plus	2.25 Dinars per KWh

Variant "B" 1961-1962

Capital Charges	4.35 Mils	plus	1.36 Dinars per KWh
Operation Charges	1.04 Mils	"	0.89 Dinars per KWh
Total per KWh	5.39 Mils	plus	2.25 Dinars per KWh

Table XXII

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

System Data - Operation Costs

Year	1955	1956	1957	1958	1959	1960	1961
System Data							
Average year generation 1000 million KWh	1.10	1.70	2.35	3.15	5.35	8.20	10.10
Export delivery during low water year 1000 million KWh	0.83	1.28	1.77	2.36	4.02	6.15	7.57
Power plants capacity in MW	300	450	675	850	1 450	2 050	2 450
Capital cost of transmission lines							
Million Dollars	5.06	13.65	16.55	16.55	22.20	30.20	38.50
Million Dinars	5 000	14 000	17 000	17 000	23 000	32 000	40 000
Capital cost of system							
Million Dollars	40.06	63.65	86.15	99.75	177.90	251.90	314.70
Million Dinars	29 000	48 000	64 000	74 000	128 000	181 000	219 000
Operation Cost Foreign Currency Part							
Power plants operation cost Thousand Dollars	120	180	270	340	580	820	980
Transmission lines operation cost Thousand Dollars	51	137	166	166	222	302	385
Amortization Thousand Dollars	852	134	1 810	2 090	3 770	5 280	6 490
Total foreign currency Thousand Dollars	1 023	1 657	2 246	2 596	4 572	6 402	7 855
Low water year Mils per KWh	1.23	1.29	1.26	1.10	1.14	1.04	1.04
Operation Cost Local Currency Part							
Power plants operation Million Dinars	216	324	485	612	1 045	1 475	1 760
Transmission lines operation Million Dinars	50	140	170	170	230	320	400
Amortization Million Dinars	610	1 010	1 350	1 550	2 690	3 800	4 600
Total local currency Million Dinars	870	1 474	2 005	2 332	3 965	5 595	6 760
Low water year Dinars per KWh	1.05	1.15	1.13	0.99	0.98	0.91	0.89

Table XXIII

ELECTRIC ENERGY EXPORT SYSTEM OF YUGOSLAVIA

Cost of Exportable Energy during a low water year Years 1955-1990

	Foreign Currency Mils per KWh						Local Currency Dinars per KWh		
	Variant "A"			Variant "B"			Variant "A" and "B"		
Year	Capital Cost	Operation Cost	Total	Capital Cost	Operation Cost	Total	Capital Cost	Operation Cost	Total
1955	20.00	1.23	21.23	10.00	1.23	11.23		1.05	1.05
1956	20.00	1.29	21.29	10.00	1.29	11.29		1.05	1.05
1957	20.00	1.26	21.26	10.00	1.26	11.26		1.13	1.13
1958	15.50	1.10	16.60	10.00	1.10	11.10		0.99	0.99
1959	10.90	1.14	12.04	10.25	1.14	11.39		0.98	0.98
1960	5.73	1.04	6.77	6.30	1.04	7.34		0.91	0.91
1961	3.26	1.04	4.30	4.35	1.04	5.39	1.36	0.89	2.25
1962	3.40	1.04	4.44	3.76	1.04	4.80	2.37	0.89	3.26
1963	3.36	1.04	4.40	3.55	1.04	4.59	2.33	0.89	3.22
1964	3.30	1.04	4.34	3.47	1.04	4.51	2.29	0.89	3.18
1965	3.23	1.04	4.27	3.39	1.04	4.43	2.26	0.89	3.15
1966	3.16	1.04	4.20	3.32	1.04	4.36	2.21	0.89	3.10
1967	3.09	1.04	4.13	3.24	1.04	4.28	2.17	0.89	3.06
1968	3.01	1.04	4.05	3.16	1.04	4.20	2.13	0.89	3.02
1969	2.95	1.04	3.99	3.09	1.04	4.13	2.10	0.89	2.99
1970	2.86	1.04	3.90	3.02	1.04	4.06	2.05	0.89	2.94
1971	2.81	1.04	3.85	2.95	1.04	3.99	2.01	0.89	2.90
1972	2.74	1.04	3.78	2.85	1.04	3.89	1.96	0.89	2.85
1973	2.67	1.04	3.71	2.78	1.04	3.82	1.92	0.89	2.81
1974	2.60	1.04	3.64	2.70	1.04	3.74	1.88	0.89	2.77
1975	2.54	1.04	3.58	2.64	1.04	3.68	1.84	0.89	2.73
1976	2.47	1.04	3.51	2.56	1.04	3.60	1.80	0.89	2.69
1977	2.39	1.04	3.43	2.50	1.04	3.54	1.76	0.89	2.65
1978	2.32	1.04	3.36	2.41	1.04	3.45	1.72	0.89	2.61
1979	2.25	1.04	3.29	2.33	1.04	3.37	1.68	0.89	2.57
1980	2.19	1.04	3.23	2.27	1.04	3.31	1.64	0.89	2.53
1981	2.12	1.04	3.16	2.19	1.04	3.23	1.60	0.89	2.49
1982	2.03	1.04	3.07	2.12	1.04	3.16	1.56	0.89	2.45
1983	0.99	1.04	2.03	2.08	1.04	3.12	1.52	0.89	2.41
1984	0.92	1.04	1.96	0.69	1.04	1.73	1.47	0.89	2.36
1985	0.89	1.04	1.93	0.61	1.04	1.65	1.44	0.89	2.33
1986	0.87	1.04	1.91	0.02	1.04	1.06	0.04	0.89	0.93
1987	0.03	1.04	1.07		1.04	1.04		0.89	0.89
1988		1.04	1.04		1.04	1.04		0.89	0.89
1989		1.04	1.04		1.04	1.04		0.89	0.89
1990		1.04	1.04		1.04	1.04		0.89	0.89

67

M. PROPOSALS FOR THE ORGANISATION OF INVESTIGATIONS, DESIGNING, CONSTRUCTION AND OPERATION OF THE YUGOSLAV ENERGY EXPORT SCHEME

In the complicated political conditions, when four countries - Yugoslavia, Italy, Austria and Germany, as well as four Republics of the Yugoslav Federation - Montenegro, Bosnia-Herzegovina, Croatia and Slovenia - are involved, the successful development of an energy export scheme will largely depend on the organisation that will have to be created to handle the problems.

All the time and cost estimates quoted in this report are based on the assumption that the investigations, designing, construction and operation will be conducted efficiently and speedily. This will, obviously, involve the necessity of providing the organisation in charge of investigations, designing and construction with the necessary amounts of foreign and local currency.

Although the financial considerations are of vital importance they do not by any means insure efficiency, speed and economy. The construction time schedule and the costs can be kept within the prescribed limits if a proper organisation is created to conduct the work. And this organisation must be much more efficient than any organisation of similar kind operating in Yugoslavia at present.

This organisation should be authorised to handle the problem of energy exports from Yugoslavia in its entirety, including the negotiations, investigations, designing and construction, as well as the operation of the projects. The work of this organisation should not be encumbered with an excessive amount of red tape. It should have freedom to obtain the necessary equipment, make contracts for designs and construction and obtain technical advice and assistance from any place or organisation in Yugoslavia or abroad. It should also have the freedom to employ and discharge Yugoslav and foreign personnel and establish individual payment rates, based on merit only, that would fluctuate within much wider limits than those accepted in Yugoslavia at present.

The attached organisation chart shows in a simplified form how it would be possible to keep the international problems and the problems involving

the Yugoslav Republics separated from the engineering problems that should be under a centralised guidance. (Fig.VI)

This chart provides for a chairman of the organisation who will be in complete charge of the whole enterprise. His duties will include the guidance of the Yugoslav members on foreign committees as well as the coordination of the Yugoslav inter-republican committees. Directly under the Chairman and reporting to him only will be the responsible chief engineer who will handle all engineering problems as well as the economic and financial problems directly connected with the engineering ones.

The chief engineer should be authorised to get the assistance of engineering and other organisations in the individual Republics. The necessity and extent of such assistance should be left to the chief engineer s judgement.

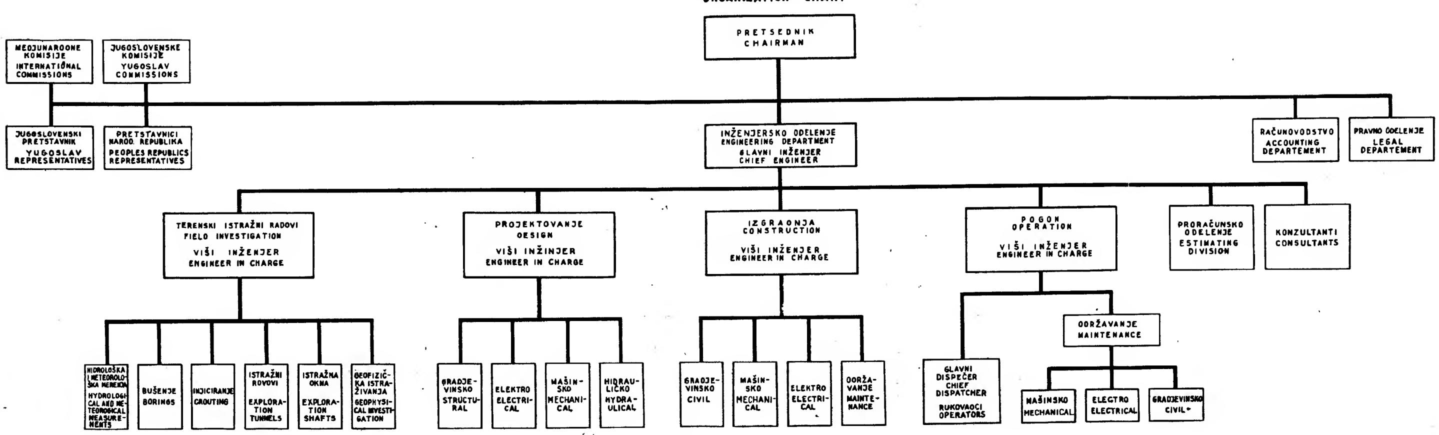
It is believed that if such a division of authority and responsibility is accepted, a workable and simple organisation could be created and one capable of realising the energy export scheme within the shortest time and at the lowest cost.

Fig 6
Report by
A.V. KARPOV

IZVOZ ENERGIJE IZ JUGOSLAVIJE
EXPORT OF ENERGY FROM YUGOSLAVIA

KOMISIJA SAVEZNE VLADE ZA IZVOZ ENERGIJE
FEDERAL GOVERNMENT COMMISSION ON EXPORT OF ENERGY

ORGANIZACIONA SHEMA
ORGANIZATION CHART



N. CONCLUSIONS

It would be in the interest of Yugoslavia to start the export of electric energy as soon as physically possible. That is important from two viewpoints: First, it will shorten the period of time that has to pass until the foreign currency income of the system can be made available to Yugoslavia. Second, and that is probably more important, it will create an atmosphere in which the negotiations can be carried with the best advantage for Yugoslavia. To speed up the delivery of energy and to gain an advantageous position Yugoslavia should take the initiative in this matter.

By utilising the Jablanica power plants, the construction of which has already reached a fairly advanced stage, and some of the plants that could be made available in Slovenia by 1955 Yugoslavia could have the advantage of being able to export about 1 000 million KWh beginning with the winter 1955-1956. After this early start the amounts exported could be gradually increased in every subsequent year until in 1961 the annual total reached about 10 000 million KWh.

Such a program involves in the course of the next eight years the installation of about 2 500 000 KW of hydro turbo-generator capacity in export power plants and the building of about 2 500 km. of high tension transmission lines. This is an ambitious program but if the financial problems are settled by the middle of 1953 and if Yugoslavia decides to tackle the problem in an efficient manner, the program is entirely feasible. Given these conditions, the initial energy delivery dates indicated in this report could be adhered to.

To attain these objectives, it will be necessary to create immediately the energy export organisation and to put a Chairman and a responsible Chief Engineer in charge of it. These two should appoint the necessary staff so that all engineering, economic and financial phases of the individual projects and of the complete system could be worked out.

This Energy Exporting Organisation should start its work even before the opening of conferences with foreign countries and negotiation of financial arrangements. This organisation should prepare concrete and concise technical projects of power plants, substations, transmission lines and proposed operation schedules. These projects should be prepared speedily and in such a way that they might easily be understood and discussed by the representatives of foreign countries.

To make possible a speedy preparation of these data it would be necessary to speed up the investigation work on projects where such work has already

been started and immediately begin the investigation work on projects where nothing or very little had been done so far.

The power plants and transmission lines suggested in this report have been selected with particularly careful consideration as to the possibility of completing their construction and putting the various parts of the system in operation in accordance with the time schedule given in this report. It is believed that the scheme is entirely realistic and if the necessary financial support is obtained, it would be put through by a responsible organisation within the time limits suggested in the report.

The energy should obviously be sold above cost. The selling price should be such as to enable Yugoslavia to obtain a substantial profit in each operation year. If all expenses and capital charges are paid and the amortisation charges are set aside in an amortisation fund, Yugoslavia will have, beside profits accruing during operation years, an Energy System in first class condition. After 1987, the loan and investment charges will be discontinued and the System will be free from any financial obligations. Such a state of affairs may not be realised in practice if it is deemed desirable to expand the system from time to time and to invest some of the profits in such undertakings.

It would be advantageous for Yugoslavia to use the foreign currency that will be made available after the energy export system has been put in operation to speed up the industrialisation of the country. It would be of advantage o attain as soon as possible such a stage of development in which Yugoslavia ould use all the energy it would be generating by that time. After that is accomplished Yugoslavia would continue to export a large amount of winter energy and import a correspondingly large amount of summer energy. Such a pattern of energy exchange would be advantageous to the foreign countries which might, therefore, be willing to continue paying a high price for imported winter energy and charge a low price for exported summer energy. The advantages of such an arrangement to Yugoslavia are obvious.

It must be constantly borne in mind that every delay in handling the energy export problem will be of considerable disadvantage to Yugoslavia. It will also be disadvantagoous if Yugoslavia does not take the initiative in this matter.

The data included in this report could be divided into three categories:

1. Reliable data regarding the time schedules of completion and initial operation dates for projects and transmission lines.

2. Less reliable data concerning the estimated energy generation for various projects. These data must be corrected as time goes on and more measurements of railfall, snow accumulation and river and spring discharges become available. It is possible that some of the present estimates are too low and some too high.

3. Unreliable cost data. These data must be considered only as an indication of the order of capital cost and of the cost of energy generation. Extensive additional work must be done to obtain more reliable cost estimates.

Report
by
A.V.Karpov

A T T A C H M E N T "A"

BOHINJSKO JEZERO
BOHINJ LAKE

Belgrade
M a y 1953

VISIT TO THE BOHINJSKO JEZERO PROPOSED POWER DEVELOPMENT

December 5,1952

By

A.V. Karpov, Consulting Engineer, United Nations Technical Assistance Administration, Mission to Yugoslavia

1. This project contemplates the use of the natural Bohinjsko Lake which at present drains its water through the Sava Bohinjka into the Sava River. By building a low dam the river outflow of that lake would be stopped and the water taken by a 15 kilometer long tunnel to the Doblar reservoir on the Soča River at Prapetno.

2. This project represents the most promising storage reservoir development that could be put in operation faster than any other projects under consideration at the present time.

3. The proposed scheme of operation is to utilise in the summer only the natural inflow of the lake to cover the daily peaks of the systems, keeping the level of the lake practically constant. During the winter time, the lake would be drawn down through the 120 MW power plants and would be able to deliver 100 million KWh in addition to the 200 million KWh of energy that could be delivered to cover the daily summer peaks.

4. Certain difficulties are expected in the driving of the tunnel. The experience gained in 1905 in driving a tunnel through the same ridge indicates the occurrence of large amounts of water when the limestone formations are crossed.

5. The presence of that water creates two problems. First, to find out if there is any additional water that could be diverted into the lake and second to provide conditions under which the tunnel could be safely driven.

6. Due to the high head (370 m.), additional water that could be diverted into the lake is very valuable. It is estimated that each m^3 of water represents a value of four dinars. Under this assumption, every m^3 per second continuously delivered to the reservoir is worth 126 million dinars per year.

The water that is contained in the limestone formation in all probability escapes the lake and finds its way into an adjoining valley at a lower elevation.

7. It is suggested that as a part of the investigation of this project a pilot tunnel of about 2 meters diameter would be driven through the ridge parallel to the proposed main tunnel at about 10 m horizontal distance from it and 2 m below the main tunnel. This tunnel would drain the water from the limestone formations and make the driving of the main tunnel safe. In driving the pilot tunnel all necessary precautions must be taken to safeguard the lives of the labour in case a sudden inflow of water should occur.

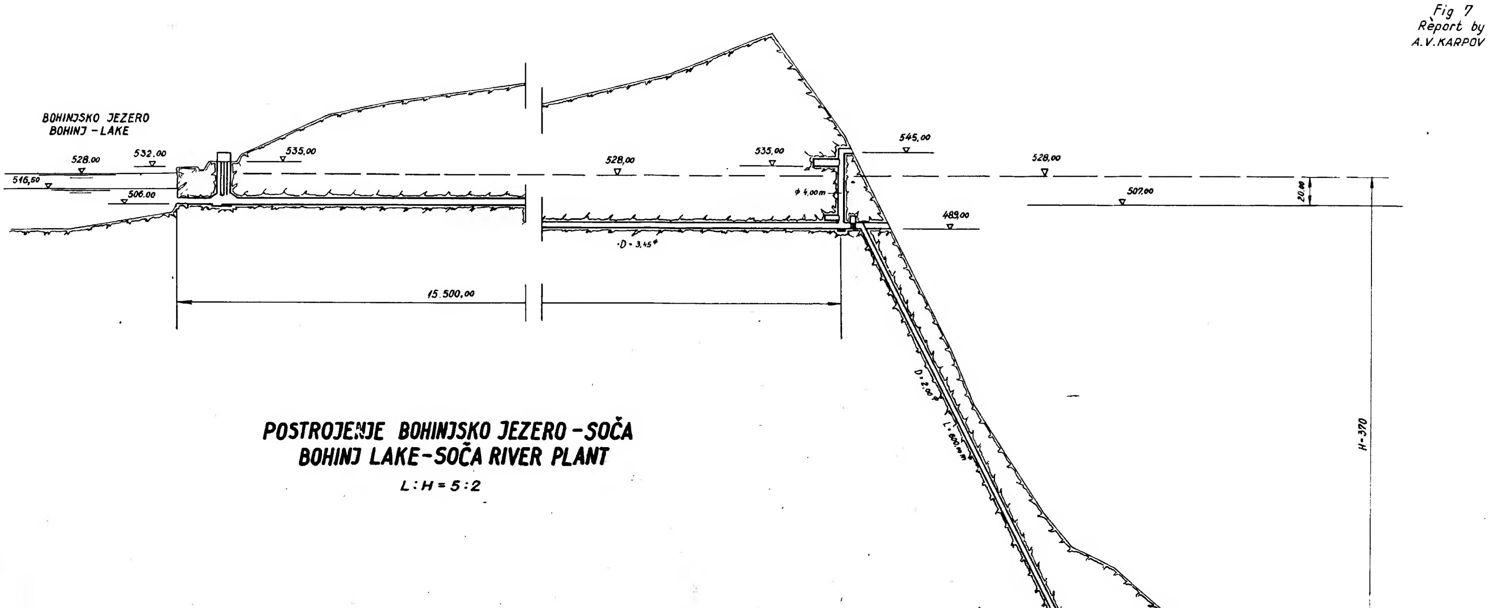
8. This pilot tunnel will be ultimately directly connected with the lake and utilised as a drain tunnel diverting at least a part of the water from the limestone formations into the lake. During the construction period the water must be pumped from the outlet of the tunnel into the lake, afterwards no pumping will be necessary. The amount of water thus obtained must be measured. After this measurement has been made through a one year period, it can be estimated how many additional drainage tunnels , and maybe also cross tunnels, can be economically justified to assure that as much water as possible could be delivered in the lake.

Ljubljana,
December 7, 1952.

(A. V. Karpov)
Consulting Engineer,United Nations
Technical Assistance Administration
Mission to Yugoslavia

The attached drawing "Bohinjsko Lake - Soča River Plant" shows the main features of the project.

Fig 7
Report by
A.V. KARPOV



Sastavio: Jng. Matej Kleidienst, 1951

Report
by
A.V.Karpov

A T T A C H M E N T "B"

CETINA RIVER

Belgrade
M a y 1953

VISIT OF THE PROPOSED HYDRO ELECTRIC PLANTS ON THE CETINA RIVER
December 18th, 19th and 20th 1953

by

A.V. Karpov, Consulting Engineer, United Nations Technical Assistance Mission to Yugoslavia.

1. The part of Dalmatia in the neighbourhood of Split possesses a number of industries chemical and others that require a large amount of electric energy. New plants are proposed to increase the industrialisation of this region. At present the Tito hydroelectric power plant supplies the major portion of the hydroelectric energy. The small power plants Manojlovac, Ruski slap and Jaruga supply additional small parts of the energy. The Tito powerplant, the largest hydroplant in Yugoslavia (60.000 KW) can supply a large amount of energy during the winter only. During summer the river flow diminishes to about 10 % of the average flow.

2. The proposed development of the Cetina River in combination with the higher located Livansko, Lamocko, Kupresko and Duvanjsko Polje and the Busko Blato are intended to increase the generating capacity to about 600.000 KW and to equalise the generation of the Tito plant by supplying from storage reservoirs larger amounts of water during the summer season.

3. The Cetina River has been inspected from Peruca to Omiš where it enters the Adriatic Sea. Due to time limitations and unsatisfactory road conditions it was impossible to visit the Livansko, Lamocko, Kupresko and Duvanjsko Polje and Busko Blato.

4. A dam is proposed on the Cetina River at Peruca which would create a reservoir in the upper portion of the Cetina River. That reservoir will deliver the water through a power house back to the Cetina River. That water will again be utilised in the Tito hydroplant and in a proposed plant at Solin or Poljica.

5. Considerable investigation work has been done at Peruca. This work has been inspected in detail. The geological conditions are such that a limestone (karst) intrusion is formed on the top of the Dolomite which forms a trough (synclinale) the edges of which are above the proposed reservoir level. No water escape therefore is possible to valleys outside of the Cetina River valley.

6. The inspection of the boring cores and the tunnels at the right and left river shore as well as a vertical shaft at the right side of the river have been carefully carried through. The impression gained is that the limestone formations are forming a number of layers interposed by either soft material or by layers of rock that becomes soft and desintegrates under the influence of air and water. A number of cavities that are large at the surface are also filled with soft material. The formation in itself appears water-impervious. In some places the water however passes through breaks in the limestone. Such breacks are irregular and in some places form sizeable canals through which water may flow that finally appears on the surface as a spring.

7. Insofar as the strength of the material is concerned, it appears that in spite of the great strength of the limestone itself displacements may occur, if sufficiently large forces are transmitted to the soft material interposed between the limestone layers. Consideration is being given to the construction of a concrete arch dam. In the lower parts of the proposed dam-side the profile is rather symmetrical and topography favours the building of an arch-dam.

At higher elevations at the right side the river the surface incline is much less than at corresponding elevation of the left side resulting in considerable dissymmetry. If an arch-dam would be constructed at the higher elevations, it would be necessary to place a very heavy concrete block to take the arch thrust at the right side.

8. Summarising these conditions it would appear that the building of an arch-dam will not be safe and very expensive. The side thrust in an arch-dam must be taken by the rock formation with the minimum displacement. The soft material interposed between the rock-formations will permit a large displacement. If an attempt will be made to wash out the soft material and replace it by cement, the established equilibrium of the rock strata will be disturbed. The interposed soft material layers are inclined and during the washing out period the rock strata will lose its support. It is also doubtful if the large cavities filled with soft materials can be satisfactorily washed out and refilled with concrete.

9. It is recommanded that a dam more suitable to the ground conditions will be built. The shortage of other material will indicate that the rockfill dam will give a more suitable solution.

10. Insofar as the possibility of loosing of water from the reservoir is concerned the danger involved seems to be over estimated. The material itself will not let any large amounts of water to pass. It is necessary to find the breaks in limestone and the channels through which the water passes or may pass. All such possible water passage channels must be closed. Practically the same work in closing of such channels will be necessary regardless of the height of water in the reservoir. There at present is considered a scheme to build the project in two steps. First to raise the dam to 35 meters and in a second step to increase the height of the dam to 50 metres. Such procedure must be considered very undesirable and the cost of the completed project will be much higher than if it is built in one step. The safety of a two step dam will be considerably lowered.

11. It does not seem advisable to limit the ultimate height of the dam to 50 metres. The height of the dam should be so determined that the cost of a cubic metre of stored water will become a minimum. The estimate supplied indicate that such minimum cost will be obtained if a dam higher than 50 metres is built. The fears expressed that with the higher dam it would be more difficult to retain the water in the reservoir do not seem to be justified. The limestone formations of this particular valley are of much higher quality than in most of the limestone valleys of Yugoslavia. The matter limits itself not to the quality of the limestone, but to the sealing of any possible water-passages. That will require a very through investigation along the line of the proposed dam by borings and sealing by grouting. This sealing line or curtain must be extended at the right and left ends of the dam so that the water could not bypass the sealing curtain.

12. It is suggested that along the centre line of the dam or parallel to it a number of uniformly and closely spaced small diameter exploration borings will be made to the depths of 150 metres below the level of the present river water. These borings should be tested for water tightness and the depths of the grouting holes should be determined on the basis of the results of these tests obtained from the exploration borings. The grouting curtain should be formed by two rows of borings located parallel of the exploration borings upstream and downstream. The exploration borings should be left intact until the grouting is completed, so that check water tightness tests can be made. It does not appear likely that many of the grouting holes should be more than 50 metres deep below the bottom of the river. The observations made indicate that the danger zone is closer to the surface and that not many water channels are formed far below the surface.

13. If grouting holes will be encountered that could not be sealed by grout, additional holes must be sunk around that particular hole and the underground cavity must be sealed in that way. If the additional grouting holes are of sufficient diameter, graded stone can be lowered so as to reduce the amount of grouting material. In the worst case, if a very large cavity is encountered, which is not very likely, it may be necessary to sink a shaft in this particular location to obtain a satisfactory sealing off.

Zagreb, December 22nd, 1952

A.V. Karpov
Consulting Engineer, United Nations Technical Assistance Administration, Mission to Yugoslavia

The attached drawings Fig.8- "Situation of the Hydroelectric Power Plants on the Cetina River - I - Location Map" and Fig. 9 - "Situation of the Hydroelectric Power Plant on the Cetina River - I - Longitudinal Profile" show the major features of the project.

Fig 8
Report :
A.V. KARPOV

SITUACIJA HIDROPOSTROJENJA NA CETINI I

SITUATION OF THE HYDROELECTRIC POWER PLANTS ON THE CETINA RIVER I.

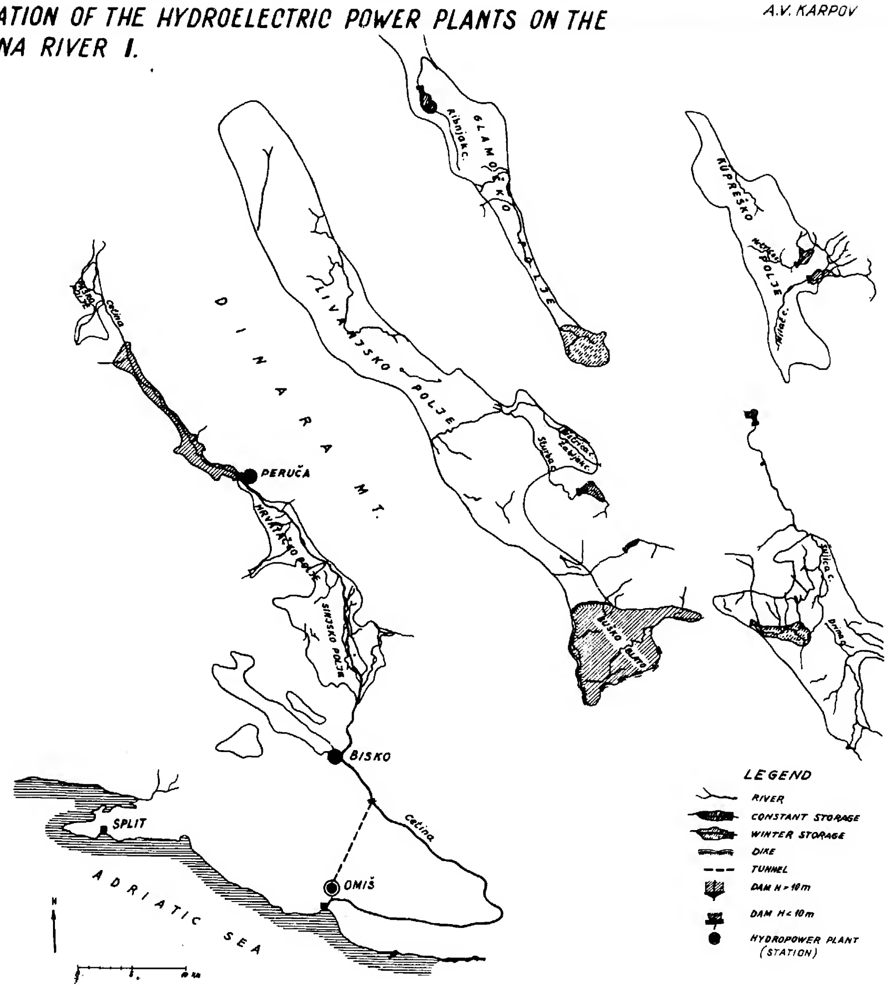
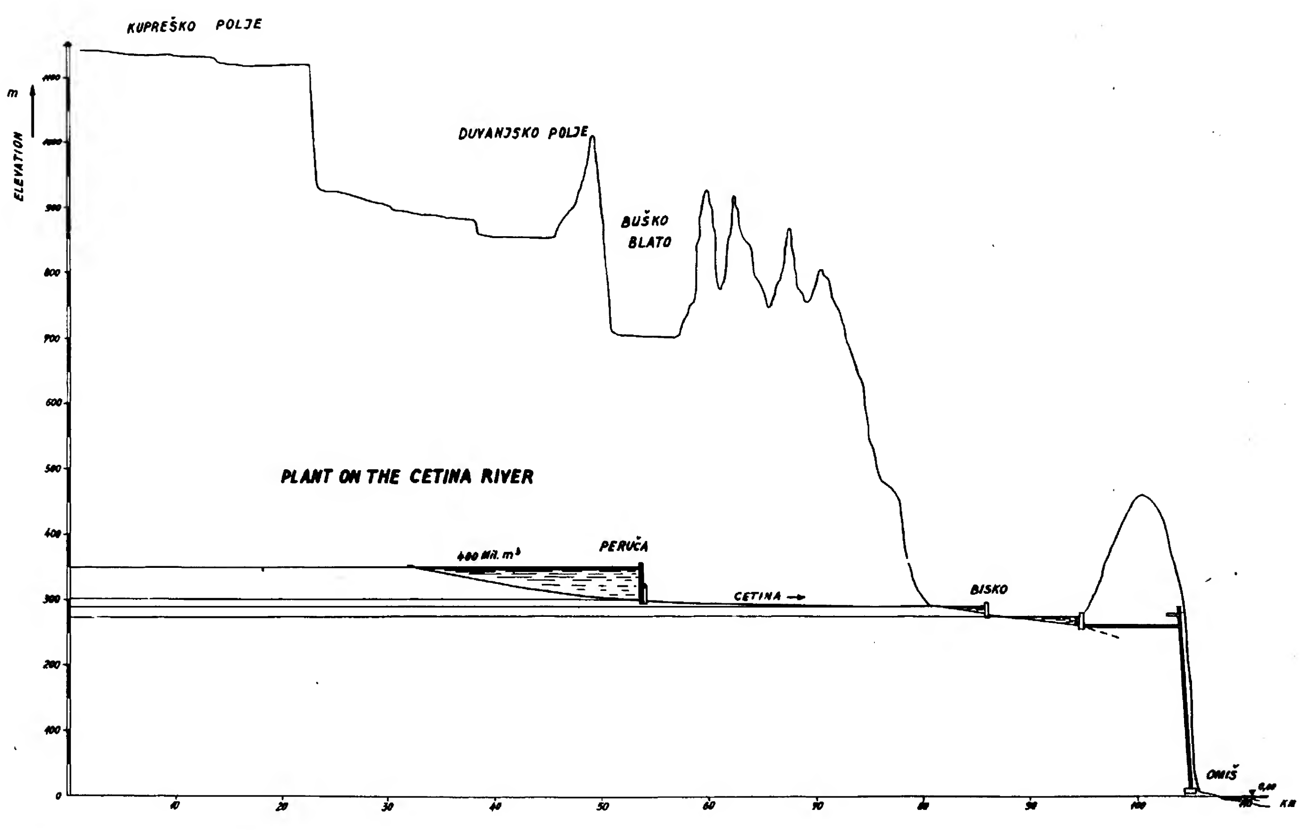


Fig 9
Report by
A.V.KARPOV

UZDUŽNI PROFIL HIDROPOSTROJENJA NA CETINI I
SITUATION OF THE HYDROELECTRIC PLANTS ON THE CETINA RIVER I
LONGITUDINAL PROFILE



Approved For Release 2010/09/10 : CIA-RDP83-00423R000900250002-3

Report
by
A. V. Karpov

A T T A C H M E N T "C"

NERETVA RIVER

Belgrade
M a y 1953

EXPORT OF ELECTRIC ENERGY FROM THE NERETVA RIVER

Conference with Elektroprojekt, Sarajevo, and visit to the proposed power plant sites on the Neretva River upstream and downstream of Jablanica.

April 7 - 8, 1953

By

A.V. Karpov, Consulting Engineer,
United Nations Technical Assistance Mission
to Yugoslavia

1. The following power plants are projected or under construction at the present time :

   a. Ulog reservoir : storage capacity about 500 million m^3, average net head at the power plant 257 m., average flow 31 m^3-sec. Energy output 550 million KWh.

   b. Glavatičevo reservoir : storage capacity about 300 million m^3, dam height about 120 m., average flow 60 m^3-sec., average net head 89 m. Energy output 370 million KWh.

   c. Ljuta reservoir : storage capacity about 20 million m^3, dam height about 40 m., average net head 40 m., energy output 175 million KWh.

   d. Jablanica reservoir : storage capacity about 300 million m^3, dam height 70 m., maximum head at the power plant 110 m., average flow Neretva 87 m^3-sec., Rama 35 m^3-sec., together 122 m^3-sec. Power plant is at present under construction which may be completed within two to four years. Energy output 714 million KWh - 144 MW - or 780 million KWh - 200 MW .

   e. Canyon section of the Neretva between Jablanica and the Šolakovac entrance into the Mostar Polje is about 60 km long and a usable head of 60 m could be obtained here. Average flow is 135 m^3-sec. Studies are being made at present to determine the most favourable number of steps in which that section of the Neretva should be developed for power purposes. (Prenj 40 m., Drežanka 20 m. - 60 m.)

   f. Downstream of Mostar Polje to Čapljina a head of about 93 m. is available. Studies are being made to determine in how many steps this stretch could best be utilised for power and irrigation purposes. (Solakovac, Bukovi, Mostar 3 x 19 m. - 4 x 9 m - 93 m.)

   g. In developing the Neretva River below Mostar, consideration is being given to the necessity of providing locks in order to make river navigation possible on the stretch between the new port of Kardeljevo and Mostar. At present Neretva is navigable for about 40 km from its mouth to the town of Metkovići. Total power output downstream of Jablanica amounts to 1710 million KWh.

2. Rama, between the Rama springs and the normal level of the Jablanica reservoir : a neat average head of 295 m. is available, storage capacity of

about 400 million m^3, average flow of 35 m^3-sec. coming from the springs. Power output 700 million KWh. (whole Neretva System 4,285 million KWh.)

3. During the discussion it transpired that no particular difficulties stand in the way of assigning the whole of the Neretva River, including the Jablanica plant under consideration and the Rama River plant, to the export of electric energy. Provisions must of course be made to cover the local demand, but this could easily be arranged by utilising first the Jajce II plant, which should be put in operation shortly and by building new hydro power plants on the Vrbas, Sana and Bosna River.

4. Certain doubts have been expressed about the possibility of delivering energy from the Jablanica plant in 1955. It was thought that the completion of the transmission line and the obtaining of additional equipment may delay the initial energy delivery date until 1956. If all the equipment required could be obtained in due time, the 1955 energy delivery date appears feasible.

5. The Jablanica power plant capacity is insufficient for the delivery of a large amount of energy in winter time. The storage capacity of this plant is also insufficient, big head losses occur in the discharge of water to the turbines and there are some other features which are not suitable for an energy export plant, which should be very reliable and absolutely safe. With the exception of the storage capacity, all the other drawbacks of the Jablanica power plant could be rectified before the plant is put in operation.

6. The increase of the Jablanica plant capacity would imply driving a third tunnel from the reservoir to the power house. If that is done, a common water collector in front of the plant would be required. The capacity increase can be achieved either by extending the cave and placing two more aggregates in the plant or by substantially increasing the capacity of the last two aggregates.

7. The shortage in storage capacity can be partly remedied by a speed development of the storage capacity of the two plants to be located on the Neretva River upstream of Jablanica. Preliminary investigation of these projects are already in such an advanced stage that it is felt that the final drawings could be prepared within a few months and construction started immediately after.

8. It would appear that the Jablanica plant and the Rama and other projects in which money has been investigated could be turned over to the electric energy export organisation. The cost of these plants could be reimbursed by the said organisation and the building of new plants to cover local demand could also be started without further delay.

9. It transpired during the above discussion that if a final decision on the export of energy were made, all the details could be agreed upon within a very short time.

Dubrovnik,
April 12, 1953

A.V. Karpov,
Consulting Engineer UN
Technical Assistance, Mission to Yugoslavia

The attached drawings Fig. 10 - "Neretva River Power System - Situation Map" and Fig. 11 - "Neretva River Power System - Longitudinal Profile" shows the presently worked out projects. The work to be done will include the reworking of the projects to reduce the number of the small power plants and increase their size.-

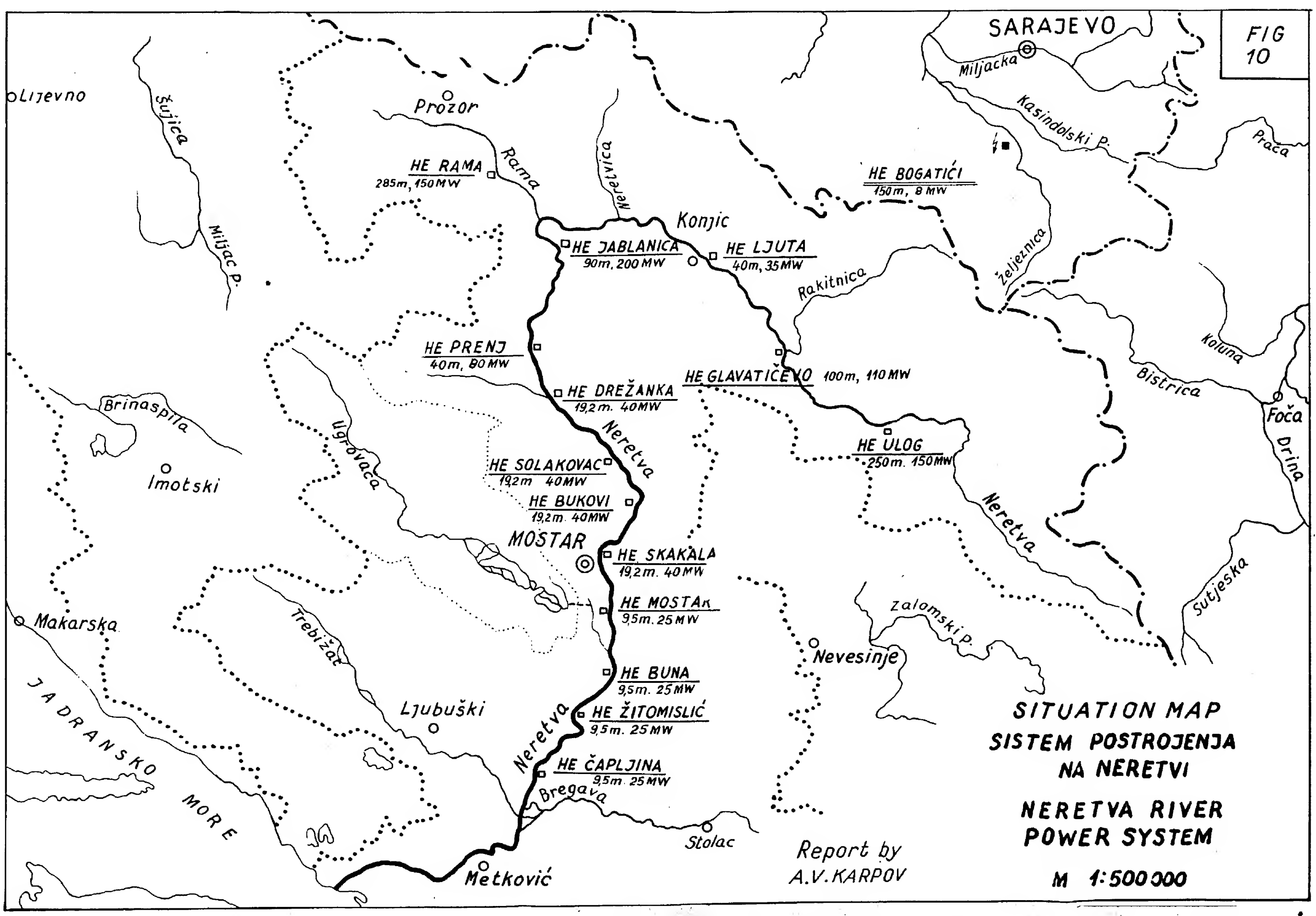


FIG 10
SARAJEVO
Miljacka
Kasindolski P.
Prača
HE BOGATIĆI
150m, 8 MW
Željeznica
Lijevno
Šujica
Prozor
Rama
HE RAMA
285m, 150 MW
Neretvica
Konjic
HE JABLANICA
90m, 200 MW
HE LJUTA
40m, 35 MW
Rakitnica
Miljac P.
HE PRENJ
40m, 80 MW
HE DREŽANKA
19,2 m. 40 MW
HE GLAVATIČEVO 100m, 110 MW
Kalina
Bistrica
Foča
Drina
Brinaspila
Imotski
Ugrovača
Neretva
HE SOLAKOVAC
19,2m 40 MW
HE BUKOVI
19,2m. 40 MW
HE ULOG
250m. 150 MW
Neretva
MOSTAR
HE SKAKALA
19,2m. 40 MW
HE MOSTAR
9,5m. 25 MW
Sutjeska
Zalomski P.
Makarska
Trebižat
Nevesinje
HE BUNA
9,5m. 25 MW
JADRANSKO MORE
Ljubuški
HE ŽITOMISLIĆ
9,5m. 25 MW
Neretva
HE ČAPLJINA
9,5m. 25 MW
Bregava
Stolac
Metković
Report by
A.V. KARPOV
SITUATION MAP
SISTEM POSTROJENJA
NA NERETVI
NERETVA RIVER
POWER SYSTEM
M 1:500000

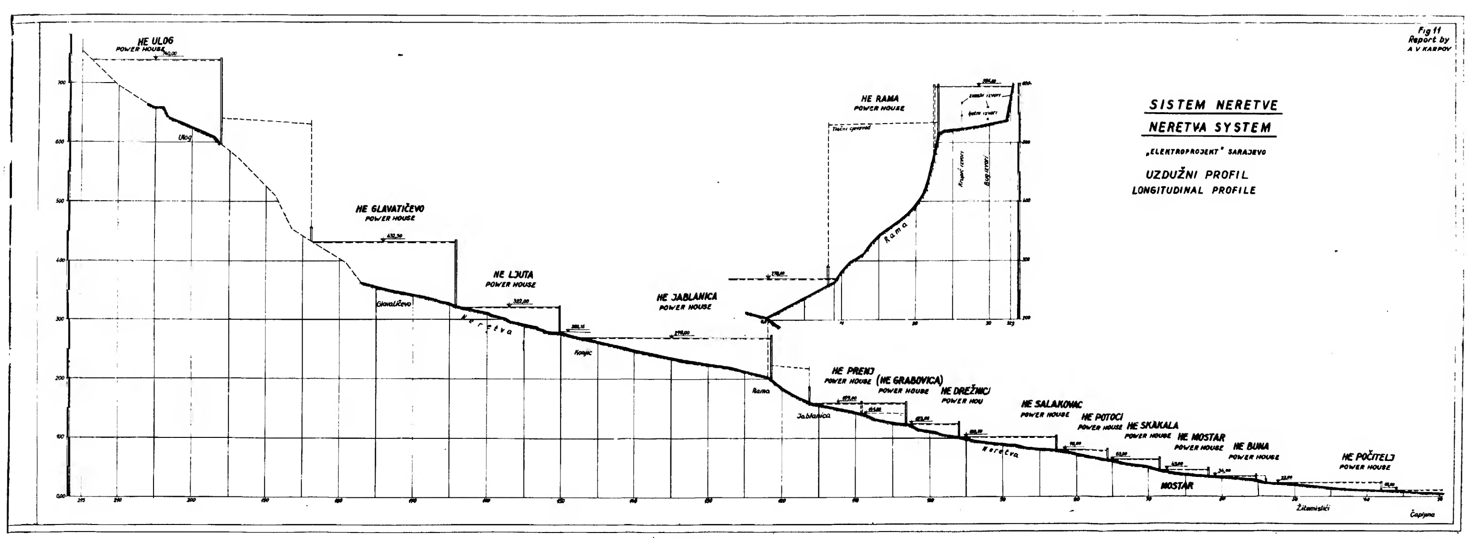


Fig 11
Report by
A V KARPOV
SISTEM NERETVE
NERETVA SYSTEM
„ELEKTROPROJEKT" SARAJEVO
UZDUŽNI PROFIL
LONGITUDINAL PROFILE
HE ULOG
POWER HOUSE
740,00
Ulog
HE GLAVATIČEVO
POWER HOUSE
432,50
Glavatičevo
HE LJUTA
POWER HOUSE
322,00
Neretva
HE JABLANICA
POWER HOUSE
270,00
Konjic
Rama
HE RAMA
POWER HOUSE
HE PRENJ
POWER HOUSE
(HE GRABOVICA)
POWER HOUSE
HE DREŽNICI
POWER HOU
Jablanica
HE SALAKOVAC
POWER HOUSE
HE POTOCI
POWER HOUSE
HE SKAKALA
POWER HOUSE
HE MOSTAR
POWER HOUSE
HE BUNA
POWER HOUSE
HE POČITELJ
POWER HOUSE
MOSTAR
Žitomislići
Čapljina
700
600
500
400
300
200

Report
by
A.V.Karpov

ATTACHMENT "D"

TREBIŠNJICA RIVER

Belgrade
May 1953

EXPORT OF ELECTRIC ENERGY FROM THE TREBIŠNJICA RIVER BASIN

Visit to the proposed power plant sites on the Trebišnjica River, to the entrance of the power canal and tunnels and to the proposed location of the Župski Zaliv power plant between Mlini and Cavtat in the vicinity of Dubrovnik

April 9 - 11, 1953

By

A. V. Karpov,
Consulting Engineer,
United Nations Technical Assistance
Mission to Yugoslavia

1. The Trebišnjica River is formed by two streams near the town of Bileće at an elevation of 327 m. The eastern stream flows from Gatacko Polje (940 m.) and the western one (Cepeljica) from Fatnica and Dabar Polje (470 m). Both of these streams are fed by a large catchmont area. The river flows to the south until it reaches the town of Trebinje where it turns to the west and flows into the Popovo Polje. Just upstream of Trebinje two tributaries join the Trebišnjica, the Susica and the Oko River, it is supposed that they collect their water in Trebinjsko Polje - a plateau with an approximate elevation of 173 m.

2. Begining from Mirusa Polje, just below the cprimgs, and up to the town of Trebinje, Trebišnjica flows in a valley that cuts an 8 km long stretch of dolomites interposed with limestone formations. It appears that these limestone formations are not karstified, the character of topography and of the geological formation is such that if a reservoir is created the escape of water from this reservoir would be very unlikely.

3. Downstream of Trebinje, the Trebišnjica flows in a valley formed in karstified limestones with a large number of ponors. As the river approaches Popovo Polje the ponors increase in number and sometimes also in size. All these ponors feed the water into the Adriatic Sea; along the seashore there are many springs some of which carry large amounts of water.

4. The capacity of ponors is not large, compared to the amount of water that Trebišnjica dischargesinto Popovo Polje. As a result, Popovo Polje is flooded in winter and many months pass before the water recedes through the ponors. Popovo Polje itself is a very fertile agricultural area with an arable surface of 8000 hectares. The long time it takes to drain Popovo Polje after the winter floods is a considerable drawback for its cultivation. Already a long time ago plans have been made to build canals and tunnels that would provide for a quicker drainage of the Polje.

5. The present combined power and irrigation project provides for the cutting off of the Trebišnjica River from the Popovo Polje and discharging the water through a tunnel into a power plant to be erected on the Adriatic Sea shore in the vicinity of Dubrovnik. Popovo Polje would then be supplied with a sufficient amount of water for irrigation purposes. This water would flow through an irrigation canal and the necessary measures should be taken to prevent water losses through the ponors.

6. A storage reservoir could be created above the town of Trebinje. If this storage reservoir is large enough the character of flow of the Trebišnjica River will make it possible to supply practically all energy available during winter.

7. The springs and the upper streams of the Trebišnjica River supply an average of 90 m^3-sec. of water. After the reservoir has been created, the springs will be covered with about 70 m. of water. Such a counter-pressure may produce a change in the regime of the springs. The present outflow of the springs represents the natural equilibrium condition that has been achieved after many thousand, perhaps even million years. The counter-pressure will substantially distort that natural equilibrium. It is possible, therefore, that the water may find a way of lesser resistence and the output of the springs may considerably decrease.

8. To retain the output of these springs on an unchanged level it would be necessary to investigate the flow of the springs more extensively. It would be desirable to drive tunnels at the height of the maximum water level in the reservoir, which tunnel would lead the spring water directly into the reservoir intercepting it at a higher elevation. The waterways leading to the lower elevation should be cut off by grouting or some other suitable means. It is possible that by creating such an inflow of small resistence the discharge of the springs will be increased.

9. An inspection of the proposed dam location near Grancarevo disclosed that instead of the rockfill dam there may be a possibility to build a concrete dam upstream of the proposed location in a narrow canyon. The advisability of choosing a concrete dam is emphasised by the difficulties of obtaining a satisfactory water discharge arrangement for a rockfill dam. The maximum amount of water that has been observed on the Trebišnjica River was 1500 m^3-sec. at Dobromani and about 900 m^3-sec. at the dam site. The overflow capacity of the dam should be made substantially higher.

10. If the geological investigation that should be made at the proposed location of the concrete dam shows satisfactory rock conditions it will be possible to build an arch dam here. Otherwise it will have to be a gravity dam. In both cases it will be possible either to obtain a sufficiently well regulated overflow capacity or to discharge the water through the dam in a number of regulated "sky jumps".

11. Very careful consideration should be given to the height of the dam that will create a storage capacity sufficient to operate the power plants so as to be able to deliver all the energy during the winter under the Trebišnjica flow conditions which vary from year to year.

12. It is proposed to build a secondary dam below the main dam near the Oko Spring. The elevation of this dam is to be such that the reservoir would not reach the tailwater of the power house which would adjoin the main dam. The designers attempt to justify such a loss of head by the wish to avoid the flooding of some areas along the river. It is proposed to move the secondary dam downstream, closer to Trebinje, to a place called Gorica. It is assumed that the dam should be so high that the reservoir would reach the tailwater level of the upstream power house. It is necessary to consider adjustments and protective measures that must be taken along the banks of the reservoir and to make estimates of costs. After that an opinion could be formed as to whether it would be more advisable to lose a certain amount of head by lowering the reservoir or to carry out the necessary adjustments. It is estimated that the storage capacity of such a reservoir would be about 20 million m^3.

13. The power house is to be located next to the secondary dam. The operation of this power house must be coordinated with the operation of the upper power house so as to provide a sufficient waterflow to be supplied to the main power house near Dubrovnik.

14. The water will flow in the Trebisnjica River through the town of Trebinje. It is proposed to build a dam on the outskirts of the town, which will force the water into a canal leading to the tunnel. At present Trebisnjica has not a sufficient water carrying capacity and the town of Trebinje is threatened by floods. When building the above project, measures should be taken to protect the town from any eventuality of flood danger. These measures could be listed as follows:

a) A protective dyke on the right bank of the river, upstream of the dam.

b) Regulating gates of sufficient capacity and with low sills to be installed at the dam permitting a quick discharge of the rapidly rising flood waters of the Trebisnjica.

c) Dredging of the Trebisnjica bed below the dam to increase its water carrying capacity.

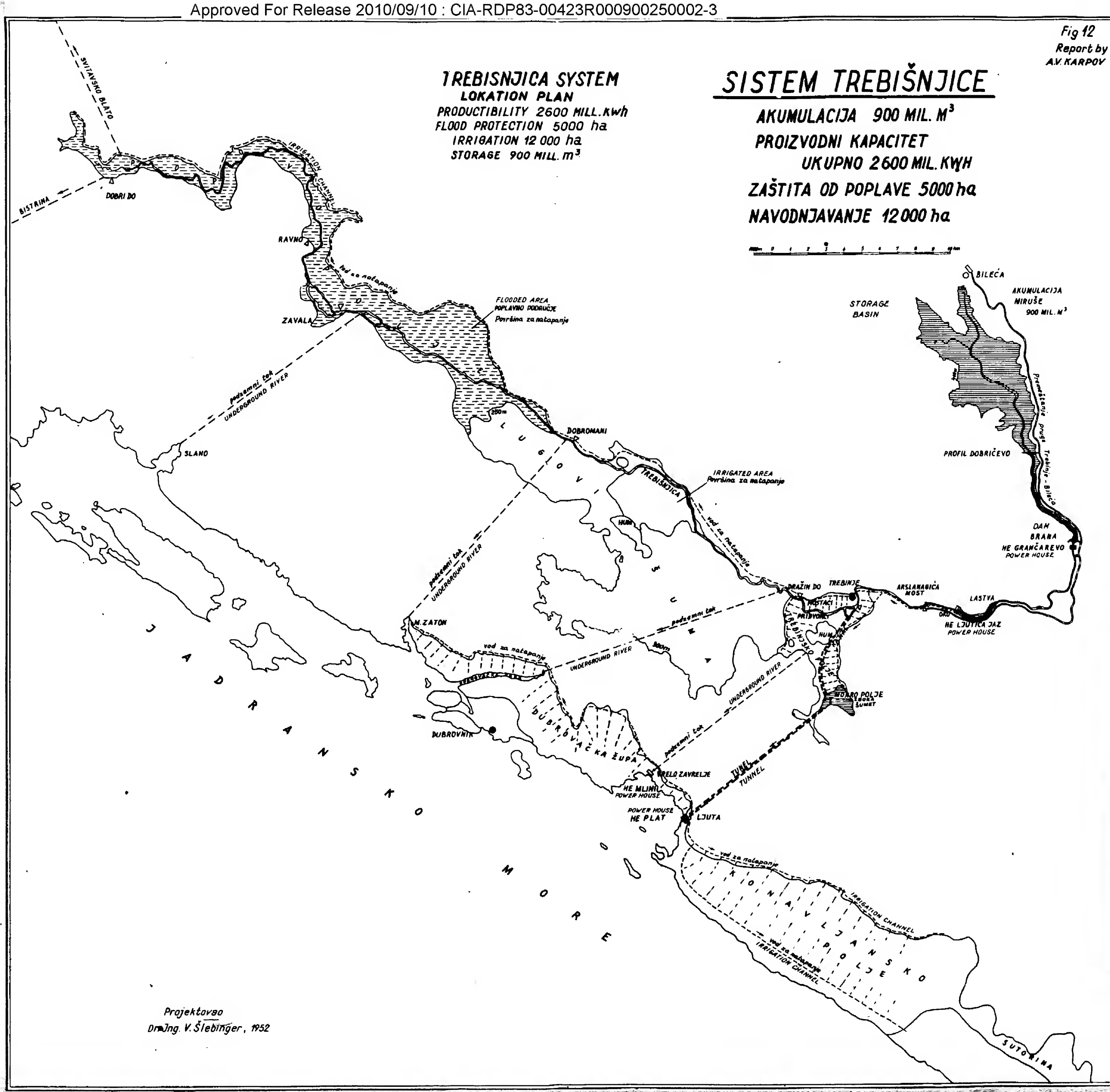
15. A natural small arm of the Trebisnjica River is to be used as an entrance to the power canal. It would be desirable to make a model of the Trebisnjica River, both above and below the dam, and of the entrance to the power canal. The purpose of the model would be to determine the most favourable configuration of the canal entrance to prevent the entry into the canal of silt, sand and stones that may be carried by the river.

16. The proposed canal should lead the water to a shallow depression called "Mokro Polje". The tunnels will start from this depression near Zgonjevo. At present, Mokro Polje collects the rain water and discharges it into a number of ponors. The purpose of using Mokro Polje was on the one hand to decrease the length of the tunnel and on the other hand to create a small regulating reservoir between the canal and the tunnel. The shallowness of Mokro Polje and the cost of sealing the ponors makes the utilisation of that depression somewhat questionable. Due to the shallowness of the depression all the dirt and sand which will be washed into it by rains will be carried into the tunnels and discharged through the turbines. If a larger storage reservoir is to be created by the erection of a dam near Gorica, the regulation could be made from that reservoir and the canal and tunnel handled as one unit. In order not to lose the flexibility of operation during sudden changes of load conditions at the main power plant, the depth of the canal should gradually increase when approaching the tunnel entrance.

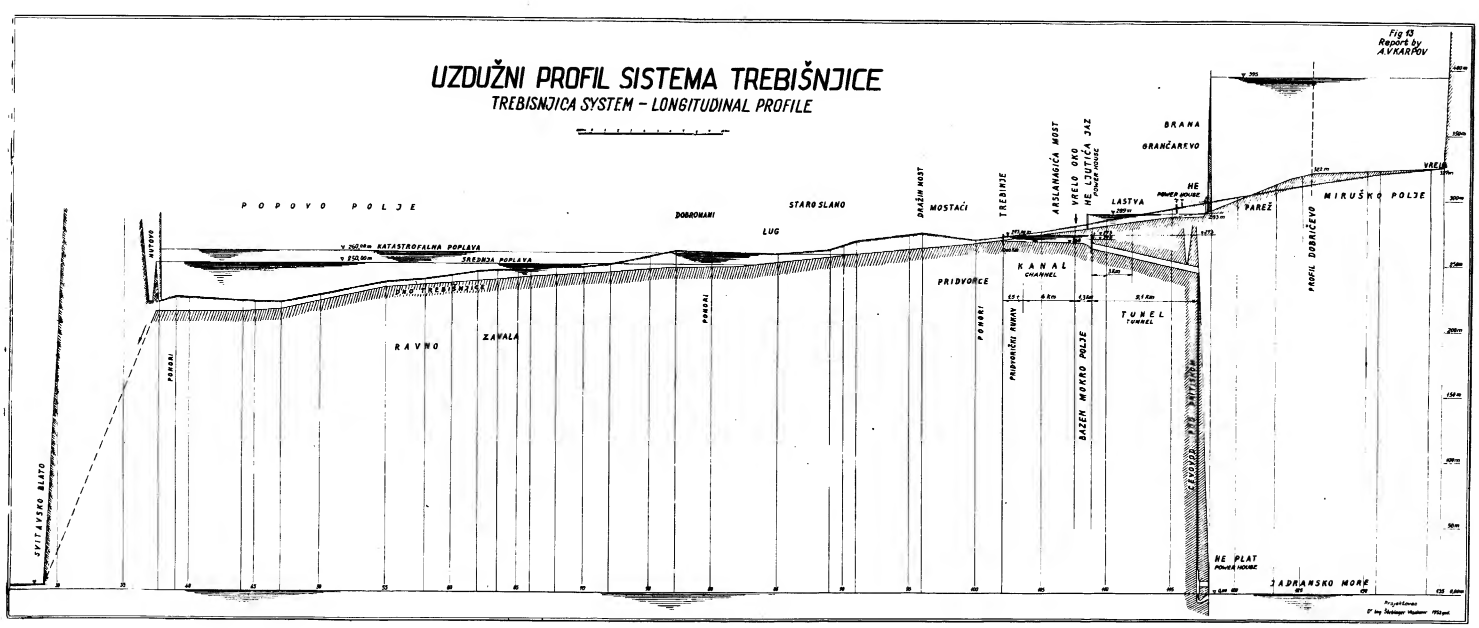
17. The original project calls for an unlined canal. The importance of the project would, however, make it desirable to have the canal lined over its whole length to prevent any losses of water or interruptions of service that may arise if the unlined canal has to be repaired.

18. The project provides for a single, some 9 km long, tunnel extending from the power canal to the main power plant on the Adriatic shore. This part of the project raises a number of questions. First, except for data obtained by surface geological observations, nothing is known regarding the rock formation through which the tunnel must be driven. It will be therefore advisable to drive a pilot tunnel before determining the final alignment of the tunnel. If the geological conditions are satisfactory, the pilot tunnel can be enlarged to the size of the power plant. If not, the alignment of the tunnel can be changed. The pilot tunnel can also be used to drain out or to pump out the water which may be

Fig 12
Report by
A.V. KARPOV



Projektovao
Dr. Ing. V. Šlebinger, 1952


UZDUŽNI PROFIL SISTEMA TREBIŠNJICE
TREBISNJICA SYSTEM – LONGITUDINAL PROFILE
Fig 13
Report by
A.V.KARPOV
POPOVO POLJE
NUTOVO
∇ 260,00 m KATASTROFALNA POPLAVA
∇ 250,00 m SREDNJA POPLAVA
DNO TREBIŠNJICE
PONORI
RAVNO
ZAVALA
DOBROMANI
LUG
STARO SLANO
DRAŽIN MOST
MOSTAĆI
PRIDVORCE
TREBINJE
ARSLANAGIĆA MOST
VRELO OKO
HE LJUTIĆA JAZ
POWER HOUSE
LASTVA
BRANA
GRANČAREVO
HE
POWER HOUSE
KANAL
CHANNEL
TUNEL
TUNNEL
PRIDVORIČKI RUKAV
BAZEN MOKRO POLJE
CJEVOVOD POD PRITISKOM
PAREŽ
PROFIL DOBRIČEVO
MIRUŠKO POLJE
VRELO
SVITAVSKO BLATO
HE PLAT
POWER HOUSE
JADRANSKO MORE

encountered in the limestone formations that have to be crossed by the tunnel. The second question concerns the size of the tunnel. The proposed tunnel has a diameter of about 8 m. If the rock formation is satisfactory, there should be no difficulty in driving such a tunnel. If, on the other hand, it proves to be unsatisfactory, it might be preferable, more expedient and more economic to drive two tunnels. Third, the small size of the tunnel and the resulting high water velocity (about 3 m per sec.) will cause a loss of about 25 m. of head in the tunnel. The proposed mode of operation of the power plant will require a full load to be delivered practically all the time during the winter. It should be determined whether the high head losses are justifiable or whether it would be more economic to increase the cross-section of the tunnels and to decrease the velocity and losses.

19. An inspection of the proposed power house site showed that a careful investigation by boring is necessary before a final location could be selected. It is proposed to start the investigation by making borings on the shore of the Zupski Zaliv, in the dolomite block north of Robinson's house.

20. If the foundation conditions at this location are satisfactory, there is a possibility to build an underground or semi-underground power house. A detailed topographic survey should be made to determine the penstock location. It appears possible to bring the water down from the tunnel in a vertical or inclined shaft and to make the penstock connections from such a shaft.

21. The material that would be brought out of the tunnel could be used to provide a level area for the outdoor switchyard. The method of connecting the power plant with the high tension transmission line will require a considerable amount of study. It may eventually prove necessary to use high tension cables to bring the energy up from the switchyard to the top of the hill where regular transmission lines could be started.

22. The only method by which the power plant equipment can be delivered will be by ship. It will therefore be necessary to provide a pier with the necessary crane facilities so that the heavy pieces of machinery can be unloaded from the ship and transferred to the power plant crane.

23. Provisions should be made in the design to prevent the sea water from entering the draft tubes of the power plant. That is particularly necessary because during summer the plant will be practically closed down and no fresh water will flow through the draft tubes.

24. The building of the project will cause a considerable decrease of the discharge of a number of springs that originate in the ponors along the Trebisnjica River downstream of Trebinje and on the Popovo Polje. Dubrovnik and some other communities may thereby experience a shortage of water. It will be necessary to adjust the conditions eventually by providing water to be pumped from the draft tubes of the main power house. For this and some other purposes it may be necessary to keep the power plant in nominal operation during the summer months.

25. It would be desirable to start without delay the investigations, the results of which are required for the preparation of blueprints for the final project. The local authorities believe that the necessary funds and authorisation to start the work will be obtained in a few days and that the investigations could be started immediately after the authorisation has been issued.

Dubrovnik,
April 13, 1953

A.V. Karpov,
Consulting Engineer,
UN Technical Assistance
Mission to Yugoslavia.

Report
by
A.V.Karpov

A T T A C H M E N T "E"

ZETA RIVER

Belgrade
M a y 1953

96

EXPORT OF ELECTRIC ENERGY FROM THE ZETA RIVER BASIN

Conferences in Nikšić and Titograd and inspection trips to Upper and Lower Zeta River. Inspection of proposed storage reservoirs, canal and tunnel locations and power plant locations.

April 14-18, 1953

by

A.V. Karpov, Consulting
Engineer, United Nations
Technical Assistance
Mission to Yugoslavia

1. The Zeta River flows from the southern end of the Nikšić Plateau passing the town of Nikšić at the approximate elevation of 600 m. After the plateau is passed there is no continuation of the river flow in the accepted sense of the word. The water is taken up by a number of ponors. The last ponor is one of the largest in Yugoslavia. It has a capacity of about 150 m^3 per sec. All these ponors lead the water through the limestone formation into the lower valley.

2. In the lower valley, at an elevation of about 40 m. the river is formed again; the ponors discharging the water in the shape of numerous springs and in some places forming effective waterfalls. In the lower valley the river passes through the city of Titograd and then joins the Morača River which discharges into the Skadar Lake.

3. The power development project aims at creating a number of storage reservoirs in the Nikšić Plateau and at intercepting the Zeta River by means of a law dam and directing it through a canal to a 3.5 km long tunnel that is to be driven through the mountain range segregating the Nikšić Plateau from the low valley of the Zeta River. In this way a bruto head of about 540 m. could be utilised.

4. The Zeta River is typical of the Yugoslav Adriatic hydro-power belt rivers. There is a considerable flow in winter which diminishes and becomes insignificant in summer. During the initial years of energy export when the amount of energy involved will not be large, it will be possible to adjust the load. It would therefore be possible in the beginning to utilise the Zeta River flow without storage. The storage facilities could be added later when the total amount of energy required for export has been increased.

5. Such an arrangement would make it possible to utilise the Zeta River energy for export at an early date. The dam on the river, the canal, the tunnel and the power house could be built and put in operation within three years. The high tension transmission line from Zeta to the distribution substation in Slovenia would also be completed within the same period of time. That would make it possible to deliver from the Zeta 0.6 billion kwh in the course of the first year.

6. The storage reservoirs may take more time to complete and it is suggested that they be completed in two steps. The completion of the first step would take one year after the power plant has been put in operation and add annually 0.2 billion kwh which could probably be completed a year later, may add another 0.2 billion kwh to the exportable total.

7. The Zeta project is located about 575 km from the distribution substation in Slovenia. The transmission line between these two points is the longest

proposed in the Yugoslav electric energy export system. This will tend to increase the cost of energy transmission and cause difficulties in operation. On the other hand, the Zeta project is most desirable from the export viewpoint because of the character of the river flow, the speed with which the run-of-river plant can be put in operation and the low cost of the project. The Zeta project is in fact the least expensive of all, both per kw installed capacity and per kwh of energy available for export.

8. The Liverici project on the Gračanica River (a tributary of the Zeta) is at present in the stage of active construction. It is a small power plant of 8,800 kw installed capacity which is intended for local purposes. Another small project designed to cover local needs, the Bjelosevina project under consideration, is to be located above the first mentioned plant on the same river.

9. A certain amount of data has been collected and some preliminary investigations carried out for the main Zeta River project. The driving of the main tunnel is to be started shortly.

10. If the Zeta River is designated for export purposes it will be necessary in the first place to go over the project in order to determine what revisions would be necessary to make it suitable for an energy export project.

11. The proposed accumulation reservoirs at the Krupacko Polje and Slano Polje do not seem to be very suitable. If they are to be utilised it would cause the loss of about 10 m. of available river head. The Krupacko Polje would not permit the raising of the level of the reservoir. The Slano Polje has a better topography and it would be possible, the geological conditions permitting, to raise the level of the reservoir here and obtain a large storage capacity without losing 10 m. of the river head. Both of these reservoirs are seemingly supplied by water from springs which do not originiate in the Zeta River. It will therefore be necessary to investigate these springs, captage them and drive tunnels that would take the water from the springs to the storage at Slano Polje. Both of the said reservoirs have ponors which ought to be investigated and subsequently sealed. These investigations would take some time to complete and might delay the completion of the reservoirs.

12. It appears that better storage reservoir possibilities exist on the Gračanica River. It would be necessary to investigate the maximum storage capacities that could be created on that river. These storage reservoirs should be included in the Zeta power project and operated as a part of the energy export system.

13. The Zeta River will be intercepted before it reaches a region where a large number of ponors, some of them of considerable capacity, are located. Before the river is intercepted it passes over a number of small ponors all of which must be located and sealed.

14. The open canal through which the water from the Zeta dam is directed to the power tunnel, must be lined to prevent any possibility of water losses and minimise the number of possible service interruptions. On the other hand, the canal should be traced in such a way as to minimise the possibility of service interruptions due to mountain slides and other causes.

15. The power tunnel does not seem to present any particular difficulties. Very careful consideration should be given to the dimensioning of the tunnel. At present it is designed for a maximum flow of 60 m^3-sec. The amount of water that should pass through the tunnel must be increased to make it suitable for the export of large amounts of energy during winter. High velocities of water in the tunnel, and, therefore, high head losses are accepted in the present design. Con-

sidering the high cost of energy to be exported in winter, high head losses would prove very uneconomical. It is, therefore, necessary to make a careful determination of the best economic cross-section of the tunnel. It would probably be advantageous to drive two tunnels instead of one.

16. There is a number of variants for the utilisation of water coming out of the tunnel. The main difference is as to whether the water is to be utilised in one or two power plants. From the export viewpoint it would be highly desirabl to have as few power plants as possible. The largest unit obtainable should be installed in each power plant. From this point of view a single power plant would be much the best solution. A reasonable solution would be to put the power house underground and at such a low level that a tailwater tunnel could discharge the water directly into the Lower Zeta. The local engineers prefer a two-powerhouse scheme. The cost of either one- or two-powerhouse scheme is practically the same. They believe, however, that the work on a two-powerhouse scheme is simpler and can be completed within a shorter time. The turbin- generator aggregates would be smaller and could, therefore, be easier obtained in Yugoslavia. The penstocks would require less steel. Topography permits the use of an upper canal from the tailwater of the first plant to the forebay of the second. The question of reducing the number of power plants and aggregates comprised in the export system is of vital importance and the whole matter should be reconsidered in the light of this statement. It may be advisable to import the penstocks and aggregates in order to build a really suitable export energy plant.

A.V. Karpov,
Consulting Engineer,
UN Technical Assistance
Mission to Yugoslavia

Titograd,
April 19, 1953

The attached Fig. 14 - "Zeta System - Location Plan" and Fig. 15 - "Zeta System - Diagramatic Longitadinal Profile" show the major features of the project. The attached Fig. 16 "Zeta River Plant - One Step Development - Overground Power House" and Fig. 17 "Zeta River Plant - One Step Development - Underground Power House" show the two variants of the proposed single power house project.

Fig. 14

Report by
A.V. KARPOV

SISTEM ZETE
AKUMULACIJE

I· 77 II· 230 III· 347 MIL. M^3

PROIZVODNI KAPACITET
UKUPNO 1300 MIL. KWH
NAVODNJAVANJE 2850 ha

ZETA SYSTEM
LOCATION PLAN

IZRADIO:
Dr. Jng. V. Šlebinger 1950

Fig 15
Report by
A.V. KARPOV

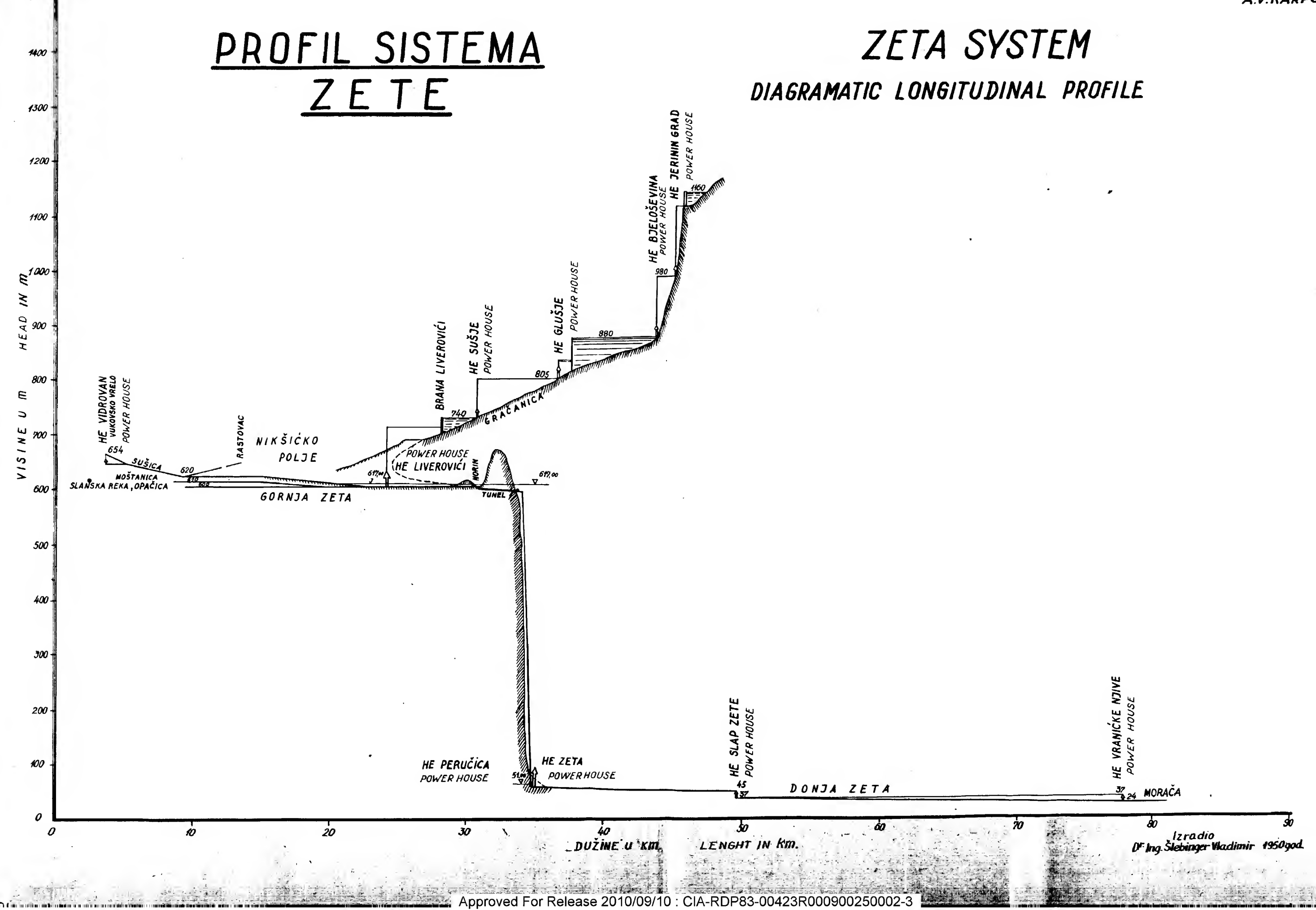
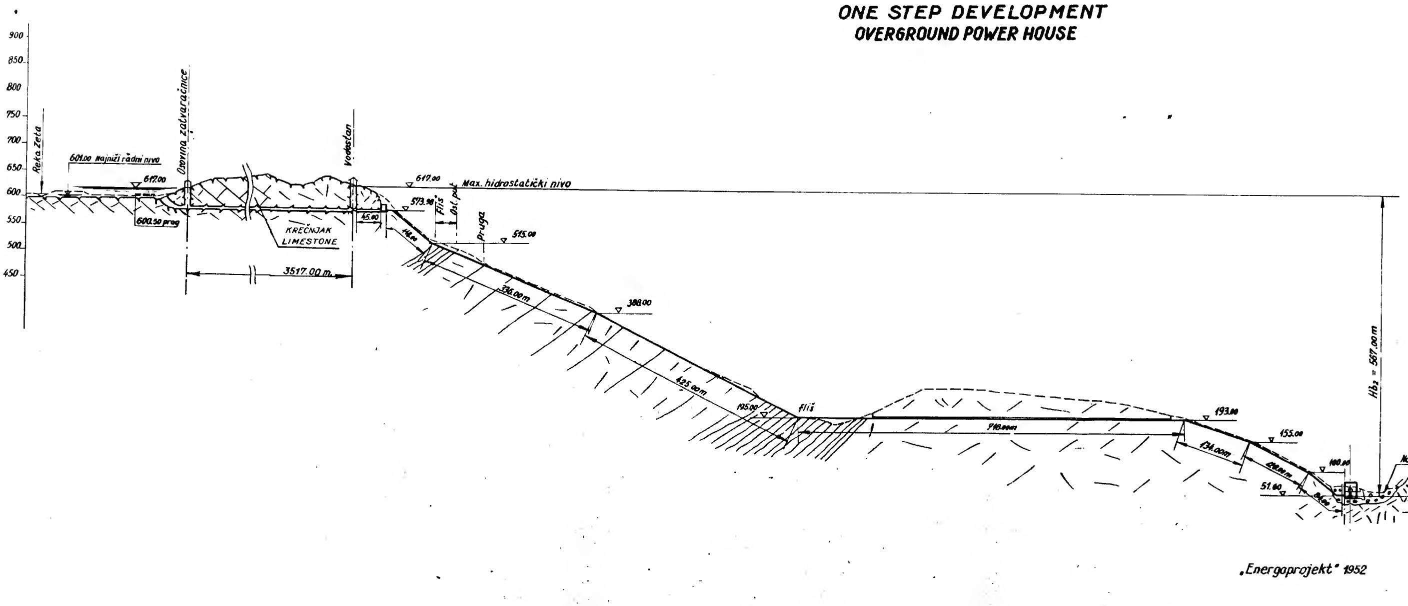


Fig 16
Report by
A.V. KARPOV

PROFIL SISTEMA ZETE
ZETA RIVER PLANT

VARIJANTA SA JEDNIM STEPENOM
POVRŠINSKA IZVEDBA
ONE STEP DEVELOPMENT
OVERGROUND POWER HOUSE

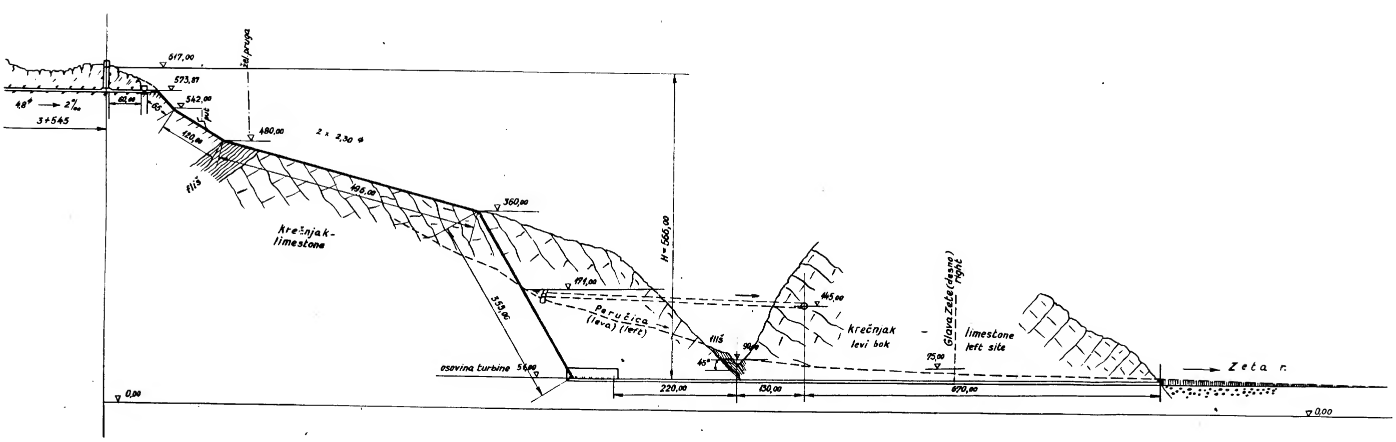


„Energoprojekt" 1952

Fig 17
Report by
A.V. KARPOV

HIDROPOSTROJENJE NA ZETI
ZETA RIVER PLANT

PODZEMNA ELEKTRANA SA 1 STEPENOM
ONE STEP DEVELOPMENT
UNDERGROUND POWER HOUSE



Sastavio Dr. Jng. V. Šlebinger